

THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 56

FEBRUARY, 1935

No. 2

NEW OR INTERESTING PHILIPPINE FERNS, VIII ¹

By E. B. COPELAND

Of the Philippine Department of Agriculture and Commerce, Manila

FOURTEEN PLATES

OPHIOGLOSSUM RAMOSII Copeland sp. nov. Plate 1, figs. 1 and 2.

O. simplici simile, majus; caule parva, ut videtur subterranea; frondibus solitariis vel 2-3 fasciculatis, usque ad 45 cm altis et 4 cm latis sine discrimine stipitis et laminae, vestigio segmenti sterilis nullo vel dubio; spica apicale, 5 cm longa, 5 mm lata, lanceolata, sporangiis lateralibus, haud interruptis, parvis.

CAMIGUIN (Mindanao), Mount Mahinag, in mossy forest; *Bu. Sci.* 14771 *Ramos*, April, 1912.

This remarkable plant has been held unnamed long enough, in the hope of more ample collection. It is now a pleasure to give it the name of its discoverer, Maximo Ramos, who lost his life in the field, May 8, 1932, after nearly thirty years of zealous and productive botanical collecting for the Philippine Government.

CYATHEA BIPINNATIFIDA Copeland sp. nov. Plate 2.

Trunco ignoto; stipite 15 cm longo, gracile, deorsum paleis 5-12 mm longis basi ultra 1 mm latis apice setaceis fulvo-griseis iridescentibus vestito, sursum pilis fulvis 3 mm longis dense vestito; fronde 25 cm longa, 10 cm lata, acuminata, basi truncata, bipinnatifida, pinnis infimis subdeflexis, rhachi setosa setis basi incrassatis; pinnis sessilibus, lineari-ellipticis, majoribus 5 cm

¹The seventh paper with this title appeared in *Philip. Journ. Sci.* 40 (1929) 291-315.

longis 1 cm latis, obtusis vel acutis, basi truncatis, pinnatifidis, costis setis deorsum dense et squamulis paucis subbullatis apiculatis interspersis vestitis; segmento infimo pinnarum inferiorum fere libero late elliptico, aliis late oblongis, 3 mm latis, subfalcatis, apice late rotundatis, integris, herbaceis, glabris; venis ca. 4-paribus, simplicibus; soris medialibus, indusiis ut videtur carentibus.

BASILAN, east of Cumalarang River, *Bu. Sci.* 16208 Reillo, September, 1912.

This fern has spent the past two decades among the undetermined specimens of *Dryopteris*. The paleæ are those of *Cyathea*, and the sporangia fix its position there; but I know no related species.

CYATHEA UMBROSA Copeland sp. nov. Plate 3.

Stipitis basi paleis nitidis aut albidis aut laete fulvis usque ad 5 cm longis et 4 mm latis apice in setam longam setuliferam aut albam aut brennescentem protensis; pinna longe (8 cm) stipitulata, 75 cm longa, fere 30 cm lata, rhachi haud dense tuberculata, fere glabra; pinnulis permultis, infimis solummodo pedicellatis, usque ad 15 cm longis, 22 mm latis, serrato-acuminatis nisi apices versus pinnatis, costis inferne squamulis albis integris plerisque ovatis 1 mm longis sparsis ornatis; pinnulis¹¹ integris, acutis, plerisque curvis, papyraceis, inferne glaucis, costulis minute et sparse squamuliferis; venis inferne conspicuis, plerisque bis furcatis; soris inframedialibus, nudis, apices versus carentibus.

LUZON, Sorsogon Province, Mount Bulusan, *Elmer* 16588, July, 1916.

This was distributed with my identification as *C. lepifera*, but new study satisfies me that it is too distinct to justify this. It is distinct in amplexity of frond, in thinness, in glaucousness, and particularly in nakedness.

Elmer 17070, from the same place, conforms satisfactorily to our cotype of *C. lepifera*, from the same general area. It is like it in denseness of tubercles and paleæ, and in firmer texture, but is more ample. The paleæ of the base of the stipe are golden in mass color, each being bordered by a narrow dark-golden line.

CYATHEA PTERIDIODES Copeland sp. nov. Plate 4.

Trunco 3.5 m alto, stipite ignoto, fronde 1 m (vel ultra) longa, 70 cm lata, rhachi dorsum 1 cm crassa sub paleis imbricatis late lanceolatis 1 cm longis albidis vel medio laete rufis dense fur-

furacea, sursum inferne tuberculis globosis nitentibus 0.5 mm diametro horrida, apicem versus rhachibusque pinnarum squamis tenuissimis ovatis laceris albidis profunde immersis; pinnis stipitatis medialibus 35 cm longis, abrupte brevi-acuminatis, pinnulis contiguis, subsessilibus, 10 cm longis, basi 18 mm latis, acuminatis, deorsum pinnatis, costis deorsum inferne dense paleaceis, sursum nudis, pinnulisⁿ resp. segmentis 3 mm latis, obtusis marginibus integris revolutis, costulis deorsum paleatis, venis inferne praestantibus, furcatis, lamina nuda, rigide chartacea; soris inframedialibus, paleis protectis, indusiis nullis.

PANAY, Antique Province, Culasi, altitude 1,500 meters, *McGregor 6061*, June, 1918.

The color, texture, and dissection give the herbarium specimen the appearance of *Pteridium*. Another representative of the small group of species known by the Javan *C. tomentosa*, *C. crinita* of Ceylon, and *C. lepifera* of Luzon (Camarines Sur): like the last in texture, but with broader pinnules and segments, less completely tripinnate, much scallier on the major axes, and naked toward all apices.

DRYOPTERIS SQUAMIPES Copeland sp. nov. Plate 5.

Dryopteris D. viscosae affinis pinnis deorsum sensim decrescentibus; caudice erecta, valida, breve; stipitibus dense fasciculatis, 5-7 cm altis, pervalidibus, atropurpureis, paleis ovatis acuminatis 5 mm longis fuscis dense vestitis; fronde 25-35 cm alta, media altitudine 6 cm lata, acuminata, deorsum longe attenuata, vix bipinnata, rhachi ubique dense ferrugineo-pilosa deorsum quoque inferne squamosa; pinnis medialibus 3 cm longis, subsessilibus, basi 1 cm latis, acutis, vix ad costam pinnatifidis, costa superne brevisetosa, inferne et pilis et paleis minutis angustis obsita; segmentis ellipticis, apice rotundatis, crenulatis, utraque facie sparse piluliferis, atroviridibus, in herbario papyraceis; venis ca. 5-paribus; soris magnis, 3- vel 4-paribus, faciem inferiorem fere obtinentibus, indusio persistente, fulvo, suborbiculare vel elongato, bullato, nudo.

MINDANAO, Bukidnon Province, Mount Lipa, *Bu. Sci. 38525 Ramos and Edaña*, "on dry, mossy forest near summit, altitude 6,600 feet."

In form of frond like many species of cooler lands, relatives of *Thelypteris*; but more nearly related, I believe, to *D. viscosa*. Growth on an exposed mountain top might cause that species to produce shorter, stouter, and more scaly stipes, but could hardly

be responsible for the gradual dwarfing of the lower pinnae. Four or more pairs of these are deflexed, and the lowest may be 15 mm long.

DRYOPTERIS PRESLIi Christ.

Dryopteris Preslii CHRIST, in Philip. Journ. Sci. § C 2 (1907) 214, non (Baker) O. K.

I have already [Philip. Journ. Sci. 40 (1929) 294] called attention to Christ's misinterpretation of this species, and am now able to place the plant he had in hand, *Cuming 354* from Bohol as represented in the Philippine National Herbarium. This is a dwarf specimen of *Dryopteris dissecta* (Forster) O. K., the largest fronds 6 by 4 cm, undissected in correlation with its size, but fertile. There is no uncertainty as to the affinity, and I am not now disposed to construe it as genetically distinct. Another dwarf, less certainly representing *D. dissecta*, is *Bur. Sci. 41134* Ramos, Coron Island, Palawan. The specimens of *Cuming 354* in other herbaria, called *Lastraea spectabilis* Presl, Epim. 38, *D. syrmatica*, etc., must be very unlike ours.

It may be observed that, if the species be construed closely, several are included under *D. dissecta*. The typical Polynesian plant has pubescent veins and almost naked lamina, the veinlets usually anastomosing here and there.

DRYOPTERIS LASERPITHIFOLIA (Scort.) C. Christ.

Dryopteris laserpitiifolia (Scort.) C. CHR.

MINDANAO, Cotabato Province, Guinatilan, altitude 800 meters, *Copeland s. n.*, September, 1933, in wet woods. Conforms to Beddome's description (Suppl. 84), except for being smaller throughout—fronds about 20 cm long on 10- to 20-cm-long stipes, the latter brownish. Only two plants were collected—not enough for a final judgment as to eventual size. No similar species has been known here previously.

DRYOPTERIS PHILIPPINENSIS (Baker) Copeland nov. comb.

Nephrodium philippinense BAKER, Ann. Bot. 5 (1891) 327.

N. caudiculatum J. SM., Journ. Bot. 3 (1841) 411, nomen.

N. extensum HOOKER, Sp. Fil. 4: 72 partim, non Blume.

Dryopteris basilaris C. CHR., Index (1905) 254; CHRIST, Philip. Journ.

Sci. § C 2 (1907) 196.

Nephrodium basilare PRESL, Epim. (1849) 258, nomen.

These names are all based on *Cuming 10*, *84*, and *338*, as listed by Baker, who seems to have been the first to provide a diagnosis for this locally common species. Christensen rejected

Baker's name because of the earlier described *Phegopteris philippinensis* Mett., *Gymnogramme philippinense* Fée, Genera 181; but this does not bar the transfer of Baker's name, because it has not itself been transferred to *Dryopteris*; also, because, I suppose, it is not a *Dryopteris* anyway, but is *Heterogonium aspidioides* Presl, although Fée and Mettenius cite *Cuming* 321, which I have not seen, and Presl cites *Cuming* 295.

The diagnoses of Baker and of Christ are alike essentially wrong in one respect—if our *Cuming* plants and theirs are alike: the plant is not glabrous. *Cuming* 84, represented by two sheets in hand, is very evidently pubescent on rachis, costa, and veins, with setulose upper surface, particularly near the margin. *Cuming* 10, the type collection, is an older specimen, and might be called glabrescent in anticipation, but no part is really glabrous; the secondary vein, running to the sinus, is most persistently bristly. *Cuming* 338 is intermediate in hairiness. Of the more recent collections cited by Christ, *Topping* 407 and *Copeland* 204 are most conspicuously hairy. *Copeland* 637 has really naked pinnæ, but is not this species. *Cuming* 10 and 84 are exceptionally large. It is a common fern along streams at minor altitudes from Cagayan, Luzon, to Zamboanga, Mindanao, but is not reported elsewhere.

DRYOPTERIS DIVERSIFOLIA (Presl) Christ.

Dryopteris diversiloba (Presl) CHRIST, in Philip. Journ. Sci. § C 2 (1907) 199.

Besides the original collections, *Cuming* 51 and 102, the only entirely typical distributed collection I know is *Bur. Sci.* 23169 *McGregor*, from Laguna, near the Tayabas boundary. It occurs, however, on Maquiling. Now, this is the type locality of *D. acromanes* Christ, t. c. 200, whence it has been distributed by *Topping*, his 735. The supposed differences are that the latter has the pinnæ more enlarged toward their apices, and the sori confined to the lobes. I believe that they are one species.

It is noted that Christ published the name *D. diversiloba* in proper binomial form, but as a subspecies of *D. canescens*; and that under it he listed a variety *acrostichoides* (no specimens cited here) with two subvarieties, *rhombea* and *lancea*. Both of the latter seem to me best to be regarded as species. There is never any difficulty in distinguishing either from *D. diversiloba*, and, while they are sometimes found together, it is almost always easy to refer each individual to one or the other.

DRYOPTERIS RHOMBEA (Christ) Copeland comb. nov. Plate 6.

Dryopteris diversiloba var. *acrostichoides* subvar. *rhombea* CHRIST, Philip. Journ. Sci. § C 2 (1907) 200.

Nephrodium acrostichoides J. SM., nomen, non Michaux.

Pronephrium acrostichoides PRESL, non *Dryopteris acrostichoides* O. K.

The type is *Cuming 149* in the Philippine National Herbarium, which Christ had on loan when he applied the name. The species ranges from Nueva Vizcaya (*Merrill 162*, cited by Christ, t. c. 199, as *D. diversiloba*) to Mindanao. It is very common at low to medium altitudes, and assumes bizarre forms in all such places. Representative distributed collections are LUZON, Bataan, *Copeland P. P. E. 18*, *Leiberg 6153*, *Merrill 3130*: Laguna, *Elmer 18205*, *For. Bur. 9550* *Curran*, *Bur. Sci. 23167* *McGregor*: Tayabas, *Topping 1306*: Camarines Sur, *Bur. Sci. 75790* *Edaño*. LEYTE, *Bur. Sci. 41756*, *Edaño*. MINDANAO, Surigao, *Bolster 252*; Agusan, *Elmer 13271*, *Merrill 7333*, *Weber 1178*: Davao, *Copeland 503*, *698*: Lanao, *Clemens 1078*: West Misamis, *For. Bur. 4613*, *4710* *Mearns and Hutchinson*: Zamboanga, *Copeland 1547*, *1754*, *1774*.

It differs from *D. diversiloba* (Presl) Christ in not being deeply nor at all regularly lobed. Only in the bizarre forms there are some long lobes, sometimes about the middle of the pinnæ, more commonly nearer their apices. The sori are usually round, but may tend to run together in pairs. Indusia may be wanting on herbarium specimens, but are present, and naked, on young sori. I have suspected that this might be *Goniopteris asymmetrica* Fée, as Christ once determined it for me, but have concluded that that must be a synonym of *D. diversiloba*; not only is it based on the same two collections, but it is described as with *frondibus pinnato-pinnatifidis*.

DRYOPTERIS LANCEOLA (Christ) Copeland comb. nov. Plate 7.

D. diversiloba var. *acrostichoides* subvar. *lanceola* CHRIST, Philip. Journ. Sci. § C 2 (1907) 200.

The type is *Copeland 250*, from Mount Mariveles. Other distributed collections are LUZON, Cagayan, *Weber 1550*: Nueva Vizcaya, *Bur. Sci. 14295* *McGregor*: Zambales, *For. Bur. 5830* *Curran*: Bataan (Mount Mariveles), *Williams 208*: Rizal, *Bur. Sci. 986*, *1807* *Ramos*, *Topping 633*, *754*, *897*: Laguna, *Bur. Sci. 9714* *Robinson*. NEGROS, *Whitford 1600*. MINDANAO, Surigao, *Bolster 261*, *Wenzel 2617*.

This species is much more uniform than is *D. rhombea*, varying only moderately in the degree of contraction of the fertile frond, and within fairly narrow specific limits in other respects.

DRYOPTERIS MAQUILINGENSIS Copeland sp. nov. Plate 8.

D. rhombeae affinis pinnis majoribus haud apices versus dilatatis; rhizomate repente, paleis fuscis parvis late lanceolatis acuminatis vestito; stipitibus arcte approximatis, stramineis setulis albidis pubescentibus demum glabrescentibus, frondium sterilius 5–10 cm, fertilius 20–30 cm altis; fronde pinnata, sterilis parte apicale 7–15 cm longa, 3–4 cm lata acuminata basi truncata, obscure vel grosse serrata pinnis lateralibus ca. 2-paribus 4–6 cm longis 2–2.5 cm latis falcato-acuminatis basi subcordato-truncatis plerumque integris carnosio-subcoriaceis, fertilis parte apicale 6–9 cm longa basi 3 cm lata deinde ad apicem acutam angustata, dentata vel basin versus inciso-dentata, pinnis lateralibus ca. 3-paribus infimis ca. 4 cm longis vix 2 cm latis plerumque undulato-crenatis; axibus minute pubescentibus; soris primo globosis, longitudinaliter seriatis; demum subconfluentibus, indusiis vestigialibus et mox evanidis.

LUZON, Mount Maquiling, altitude 350 meters. Type in Philippine National Herbarium, *Copeland*, November 1932, numero nondum praeditus, in Pterid. Philip. Exsic. distribuentum; *ibid.*, *Elmer 18169*.

While this is a relative of *D. rhombea*, I cannot bring it within the range of that very variable species. Beside the difference in form of pinnæ, obvious in dried specimens, it is in nature distinct in texture and color, being thicker and darker. Herbaria which have Elmer's Maquiling plants may compare his 18205, which is typical *D. rhombea*, and 18169, which in the Philippine National Herbarium is sterile *D. maquilingensis* with very long stipes. Except in the degree of dimorphism, *D. maquilingensis* seems to be fairly uniform—for its group.

ATHYRIUM ELMERI Copeland.

Athyrium Elmeri COPELAND, *Elmer's Leaflets* 2 (1908) 399; *Philip. Journ. Sci.* § C 3 (1908) 285. Described from Negros.

To this, I refer a plant from the west base of Mount Apo, Guinatilan, Cotabato, altitude 900 meters, in very wet forest, *Copeland*, September, 1933, with freely and sharply incised pinules. Whether this and the Negros plant are identical or not,

they are closely related, as shown by the common possession of dark-margined and toothed brown paleæ, not noted in the original description.

LOMARIOPSIS PAPYRACEA Copeland sp. nov. Plate 1, fig. 3.

Rhizomate scandente, 7 mm crasso, apice paleis castaneis lanceolatis attenuatis 6 mm longis vestito, deorsum glabrescente; frondibus plantae juvenilis simplicibus usque ad 30 cm longis, 4 cm latis, caudatis, basi longe attenuatis, stipite 10–15 cm longo, plantae normalis pinnatis, stipite 10–25 cm longo, pinnis 7-paribus vel pluribus, articulatis, subsessilibus, 15–18 cm longis, 4 cm latis, apice abrupte caudatis cauda 10–15 mm longa, basi inaequilateraliter cuneatis, papyraceis, venis conspicuis; fronde fertile 20–30 cm longa stipite incluso, pinna apicale 6–7 cm longa, 16 mm lata, lateralibus paullo minoribus.

MINDANAO, Davao Penal Colony, *Copeland*, August 30, 1932, in low, wet woods. Type in Philippine National Herbarium. Only one fertile frond found with pinnæ still present.

Related to *L. Smithii*, but distinguished by the subsessile pinnæ and the small fertile fronds with broad pinnæ. This would be identified more reasonably as *L. cochinchinensis*, from which it differs in general in the same respects. That species has not been reported from the Philippines. It might reasonably be expected in Mindanao; but I have thought it more reasonable to describe the plant in hand as new, than to report an extension of range on the strength of a very aberrant specimen; *L. subtrifoliata*, also described from Mindanao, is too different in texture to invite comparison.

DENNSTAEDTIA SCANDENS (Blume) Moore.

Hypolepis repens J. SM., non Presl.

Saccoloma moluccanum C. CHR., Index 372, as interpretation of *H. repens* J. Sm.

Hypolepis nigrescens HOOKER, Sp. Fil. 2: 66, as to the Luzon plant.

The plant in question is *Cuming* 271, of which we have two ample sheets, sterile, but unquestionably *D. scandens*. The spiny axes, which must have been responsible for Smith's wrong identification, as well as for Hooker's, make it impossible that they had *Ithycaulon* (*S. moluccanum*) in hand. *Dennstaedtia scandens* is a rare species in the Philippines, collected only five times in the last thirty years.

POLYPODIUM APOENSE Copeland sp. nov. Plate 9.

Rhizomate breve et gracile, inter baseos stipitum paleis paucis minutis fulvis obtusis vestito; stipitibus fasciculatis, filiformibus, 1–1.5 cm longis, glanduliferis; fronde 3–4 cm longa, 4 mm lata, subpinnata, tenuiter herbacea, ubique (inferne densius) pilis minutis claviformibus nitidis plerisque bicellularibus vestita; segmentis oblongis, ca. 1.2 mm latis, patentibus, obtusis vel subacutis, integris vel sinuatis, monophlebiis; soris basalibus, approximatis et interdum trans rhachin confluentibus.

MINDANAO, Cotabato, Mount Apo, altitude 2,000 meters, *Copeland s. n.*, ad truncos muscosos.

Distinguished from *P. sikkimense* Hieron., *P. pseudotrichomanoides* Hayata, and *P. pulogense* by the pubescence; in this respect like *P. glanduloso-pilosum* Brause, which by description should be firmer in texture and have subtriangular segments.

POLYPODIUM PACHYCAULUM Copeland sp. nov. Plate 10.

Ctenopteris, rhizomate breve, 5 mm crasso, radicibus, basibus stipitum et paleis atrocastaneis 6 mm longis anguste lanceolatis attenuatis irregulariter insigniter ciliatis dense immerso; stipitibus caespitosis, exarticulatis, 1–2 cm longis, rhachibusque atrofusis, pilis purpureis 1 mm longis vestitis; fronde ca. 10 cm longa, 2–2.5 cm lata, utrinque angustata, coriacea, deorsum pinnata, pinnis in parte superiore decurrenti-confluentibus, erecto-patentibus, integris, 2 mm latis, inferne pilis minutis atropurpureis dense pubescentibus superne subglabris; venis occultis, simplicibus; soris medialibus, superficialibus, demum saepe confluentibus.

MINDANAO, Cotabato, Mount Apo, altitude, 2,000 meters, *Copeland*, September 6, 1932, ad truncos muscosos.

The aspect is that of *P. nutans*, not that of any other species known to me with pubescent surfaces.

GRAMMITIS MICROTICHA Copeland sp. nov. Plate 11.

Inter *G. pleiosoram* n. comb. [*Polypodium*, Mett., *Linnaea* 36 (1869) 128] et *G. sumatranam* n. comb. [*Polypodium*, Baker, *Journ. Bot.* (1880) 214], pube stipitis 2 cm longi densa et brevissima, lamina subcoriacea minute pubescente sat dense et brevissime ciliata, ca. 12 cm longa, 10–12 mm lata, crenata, venis pluriramosis immersis, soris superficialibus, globosis, pluriseriatis vel irregulariter sparsis.

MINDANAO, Cotabato, Guinatilan (west base of Mount Apo), altitude 1,000 meters, *Copeland s. n.*, September, 1933, on mossy trunk.

Grammitis sumatrana is found higher on Mount Apo (described there as *Polyp. pleiosoroides*); it is decidedly more coriaceous, less pubescent and with rather longer hairs, and mostly elongate sori or at least receptacles.

LOXOGRAMME MAJOR *Copeland sp. nov.* Plate 12.

L. parallelae similis quondam eacumque confusa, statura majore costa stipiteque ebeneis distincta, rhizomate valido paleis 3.5–5 mm longis lanceolatis griseo-fuscis acuminatissimis integris vel hinc illinc minutissime spinulosis (parietibus cellularum excurrentibus) vestito; stipitibus 1–5 mm inter sese distantibus, 1–2 cm longis, validis, subapplanatis, ebeneis; fronde plerumque 30 cm longa, 10–12 mm lata (rarius usque ad 50 cm longa), utrinque angustata, costa nigra valida utraque facie applanata; soris 1–4 cm longis, costae fere parallelis, haud imbricatis.

MINDANAO, Cotabato, Mount Apo, altitude 1,800 meters, *Copeland, s. n.*, September 7, 1932.

This is the fern already known from the neighboring Mount Matutum and tentatively reported [*Philip. Journ. Sci.* 38 (1929) 153] as *L. parallela*. Collecting it again on Apo, and more amply, I find the greater stature to be constant, and that it is further characterized by disproportionately stouter, black stipe and costa.

The Kinabalu (Borneo) species similar in stature has been collected again by *Mrs. Clemens, 28986*. It is subsessile without black axes, in which respects it is like typical *L. parallela*.

GONIOPHLEBIUM TERRESTRE *Copeland sp. nov.* Plates 13 and 14.

Schellolepis, rhizomate late repente, gracile, 2 mm crasso, paleis castaneis persistentibus 2–3 mm longis apicibus setaceis squarrosis ubique vestito; stipitibus 8–12 cm longis; fronde 20–30 cm longa; pinnis utroque latere 3–5, maximis sterilibus 8 cm longis, 14 mm latis, valde acuminatis, basi subsessile cuneatis, irregulariter serrulatis, herbaceis, plerisque minoribus et angustioribus; venis seriem unam areolarum magnarum, rarius alteram interruptam minutarum includentibus; soris superficialibus, magnis.

LUZON, Mount Maquiling, altitude 500 meters, *Copeland*, December, 1932, ad saxas humidias.

Like *G. persicifolium* in form of pinnæ and superficial sori; distinct from this, and from *Polypodium Koningsbergeri* as de-

scribed, in the usually single row of areolæ. Abundant on one area of wet, sunny cliffs, to which the rhizomes are strictly appressed, fruiting at all seasons. Rare in the same neighborhood on mossy branches.

POLYPODIUM INCURVATUM Blume.

Reported from the Philippines from Mount Apo only, collected there by Warburg, Elmer, and three times by myself. The Apo plant, as represented in our herbaria, is atypical, being less rigidly coriaceous and with less-immersed sori than that of Java; that is, it is less completely different from the probably ancestral *P. taeniatum*.

CERATOPTERIS SILIQUOSA (Linnæus) Copeland comb. nov.

Acrostichum siliquosum LINNÆUS, Sp. Plant. (1753) 1071.

Acrostichum thalictroides LINNÆUS, *ibid.*

Ceratopteris thalictroides BRONGN. [Bull. Soc. Philom. (1821) 186, not seen], BENEDICT, Bull. Torr. Bot. Club 36 (1909) 463.

Ellobocarpus oleraceus KAULFUSS, Enum. (1824) 149.

For the numerous other synonyms see Benedict, loc. cit., and Christensen's Index. I take up the most tenable specific name, not because there is any satisfaction in a change, which there emphatically is not, but because I have material of economic interest to publish on this plant, and do not wish in a paper of essentially economic interest to discuss nomenclature, nor to use a name subject to correction.

ILLUSTRATIONS

[The photographs were prepared by the Bureau of Science. The drawings were mostly made by Alicibusan.]

PLATE 1

- FIG. 1. *Ophioglossum Ramosii* Copeland. Type, $\times 1/2$.
2. *Ophioglossum Ramosii* Copeland. Spike, $\times 1$.
3. *Lomariopsis papyracea* Copeland. Pinna, $\times 1/2$.

PLATE 2

- Cyathea bipinnatifida* Copeland. Type: 1, Fronds, $\times 2/5$; 2, pinna, $\times 4/5$; 3, paleæ, $\times 1-3/5$.

PLATE 3

- Cyathea umbrosa* Copeland. Type: 1, Pinnule, $\times 1$; 2, squamule of costa, $\times 50$; 3, palea of rachis, $\times 50$; 4, palea of stipe, $\times 50$.
Cyathea lepifera Copeland. Cotype: 5, Pinnule, $\times 1$; 6, squamule of costa, $\times 50$; 7, palea of stipe, $\times 50$.

PLATE 4

- Cyathea pteridioides* Copeland. Type: 1, Pinna, $\times 1$; 2, scale on costa, $\times 50$.

PLATE 5

- Dryopteris squamipes* Copeland. Type: 1, Mounted plant, $\times 2/5$; 2, pinna, $\times 6/5$; 3, palea from rachis, $\times 18$.

PLATE 6

- Dryopteris rhombea* (Christ) Copeland. 1, Mounted (type) plant; 2, variability of pinnæ, beginning at top, *Leiberg 6150*, Bataan; *Topping 1306*, Tayabas; *Bur. Sci. 41756*, Leyte; *Bolater 253*, Surigao; *Weber 1173*, Butuan; *Copeland 693*, Davao; *Copeland 1547*, Zamboanga; *Copeland 1774*, Zamboanga; *For. Bur. 4613*, Mount Malindang. All $\times 7/8$.

PLATE 7

- Dryopteris lanceola* (Christ) Copeland. Type: 1, Mounted plant, $\times 0.4$; 2, fertile pinna, $\times 3.2$; 3, sterile pinna, $\times 1.6$.

PLATE 8

- Dryopteris maquilangensis* Copeland. Type: 1, Mounted plant; 2, pinna, $\times 1$; 3, scale of rhizome, $\times 25$; 4, sorus, $\times 30$.

PLATE 9

- Polypodium apoense* Copeland. Type: 1, Frond, $\times 2$; 2, segment, $\times 5$; 3, fragment, showing trichomes, $\times 20$; 4, palea, $\times 60$.

PLATE 10

Polypodium pachycaulum Copeland. Type: 1, Plant before mounting, $\times 2/5$; 2, sterile fragment, $\times 4$; 3, fertile fragment, $\times 4$; 4, palea of caudex, $\times 20$.

PLATE 11

Grammitis microtricha Copeland. Type: 1, Plant before mounting, $\times 1/2$; 2, fruiting frond, $\times 1$; 3, fragment of same, $\times 2$; 4, hairs on stipe, $\times 70$; 5, hairs on lamina, $\times 70$.

PLATE 12

Loxogramme major Copeland. Type: 1, Plant before mounting, $\times 3/8$; 2, palea, $\times 20$.

PLATE 13

Goniophlebium terrestre Copeland. Type: Plant before mounting, $\times 1/3$.

PLATE 14

Goniophlebium terrestre Copeland. Type: 1, Normal pinna, $\times 1$; 2, very broad pinna, $\times 1$; 3 and 4, palæ, $\times 30$; 5, fertile fragment, $\times 1$.

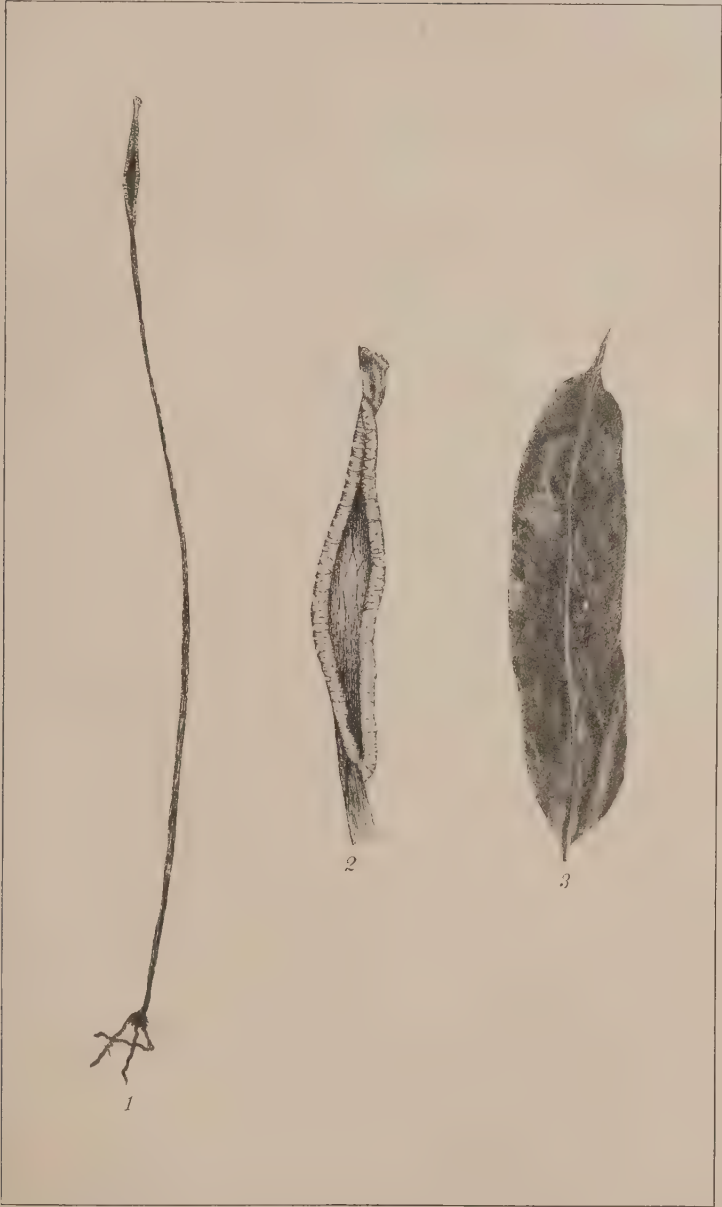


PLATE 1.



PLATE 2.

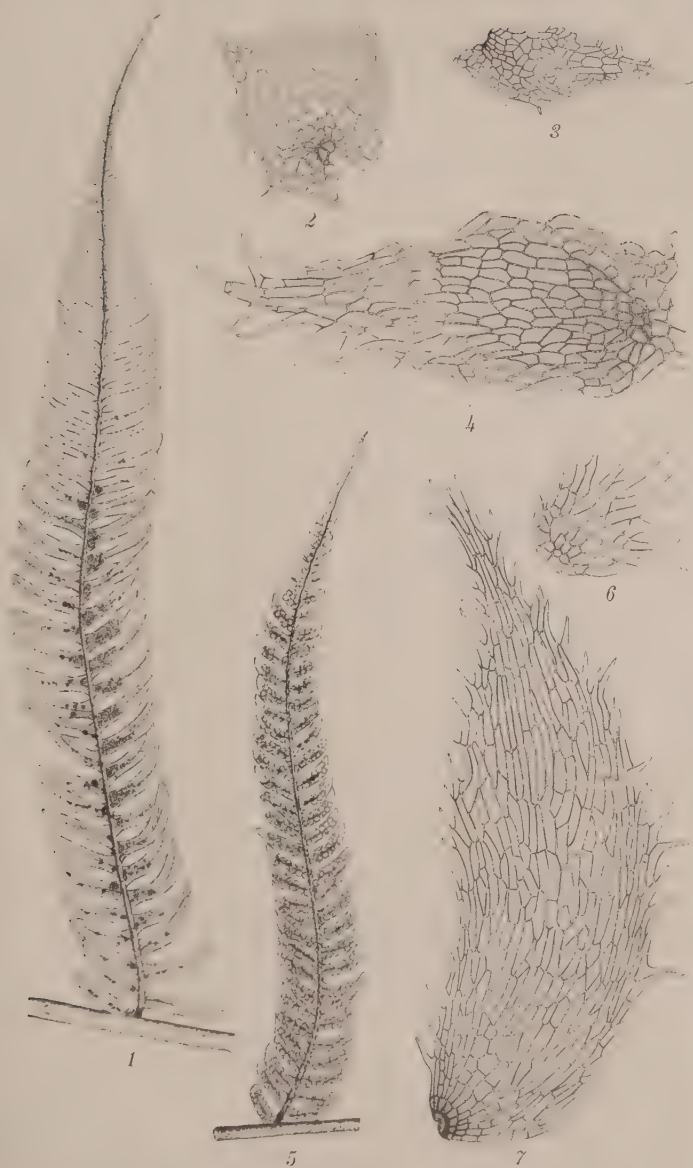


PLATE 3.

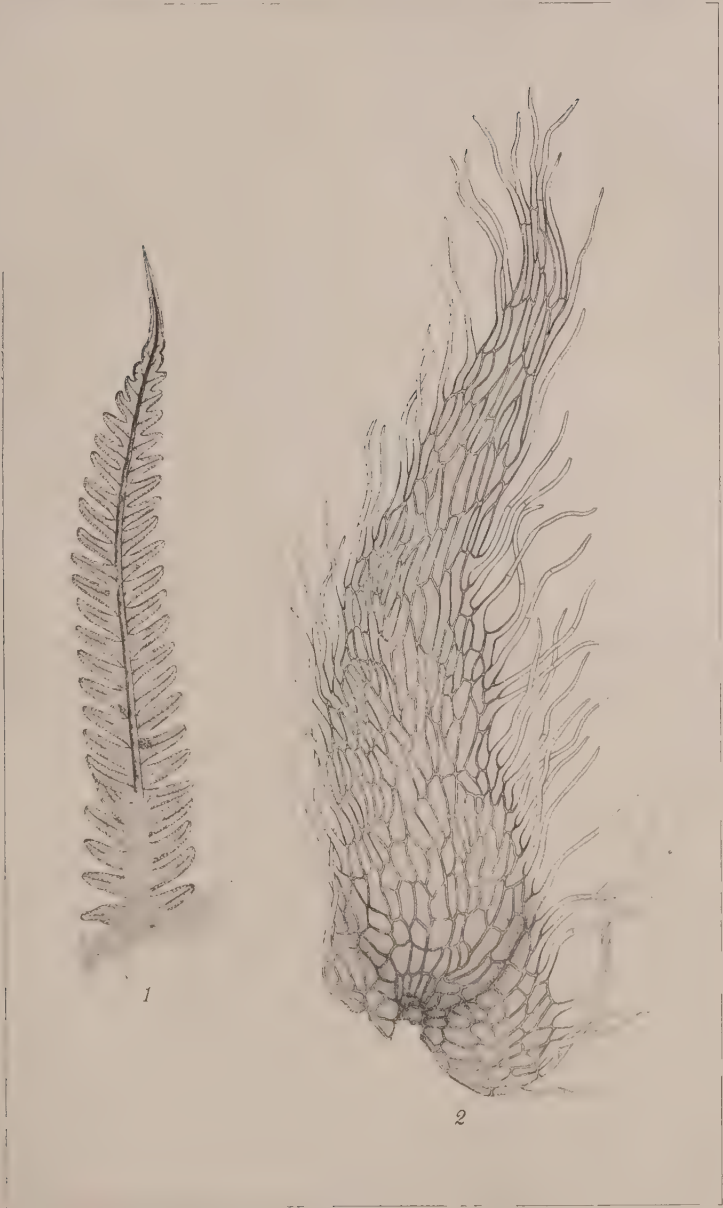


PLATE 4.



PLATE 5.

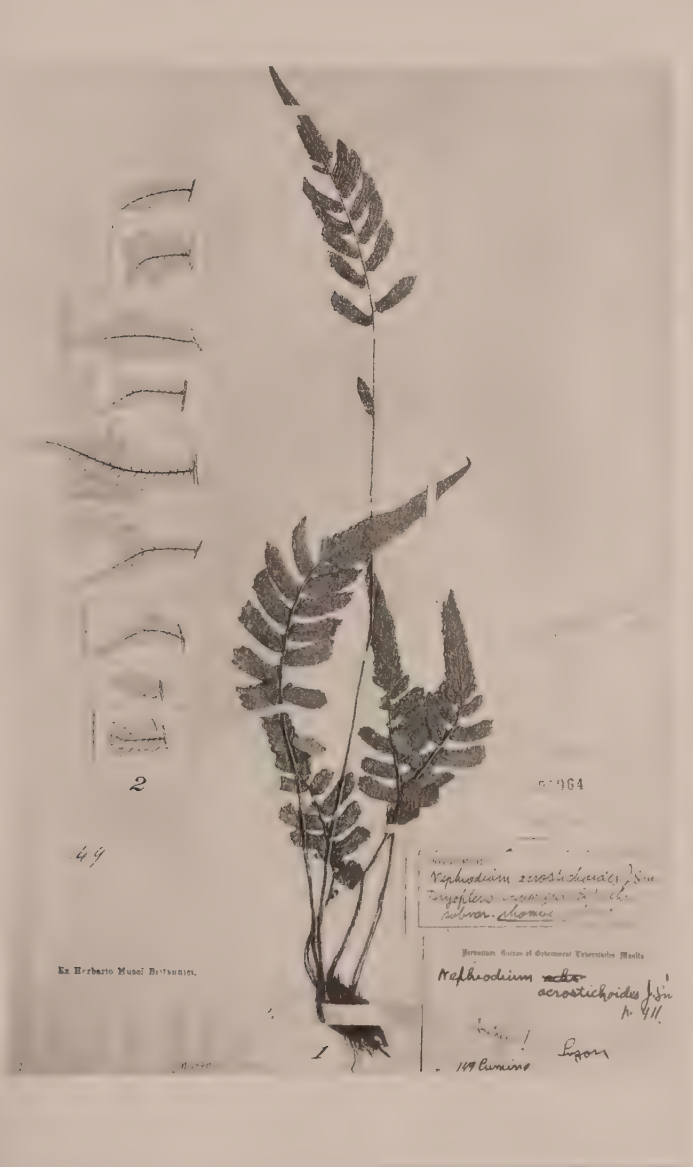
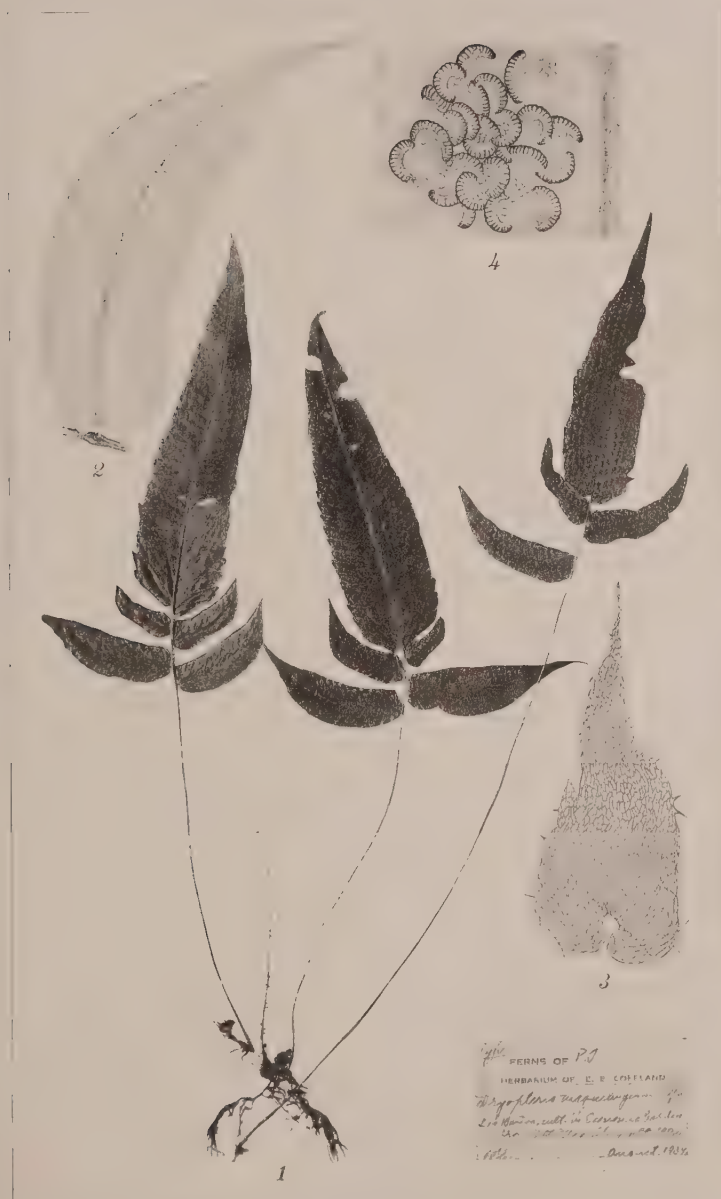


PLATE 6.



PLATE 7.



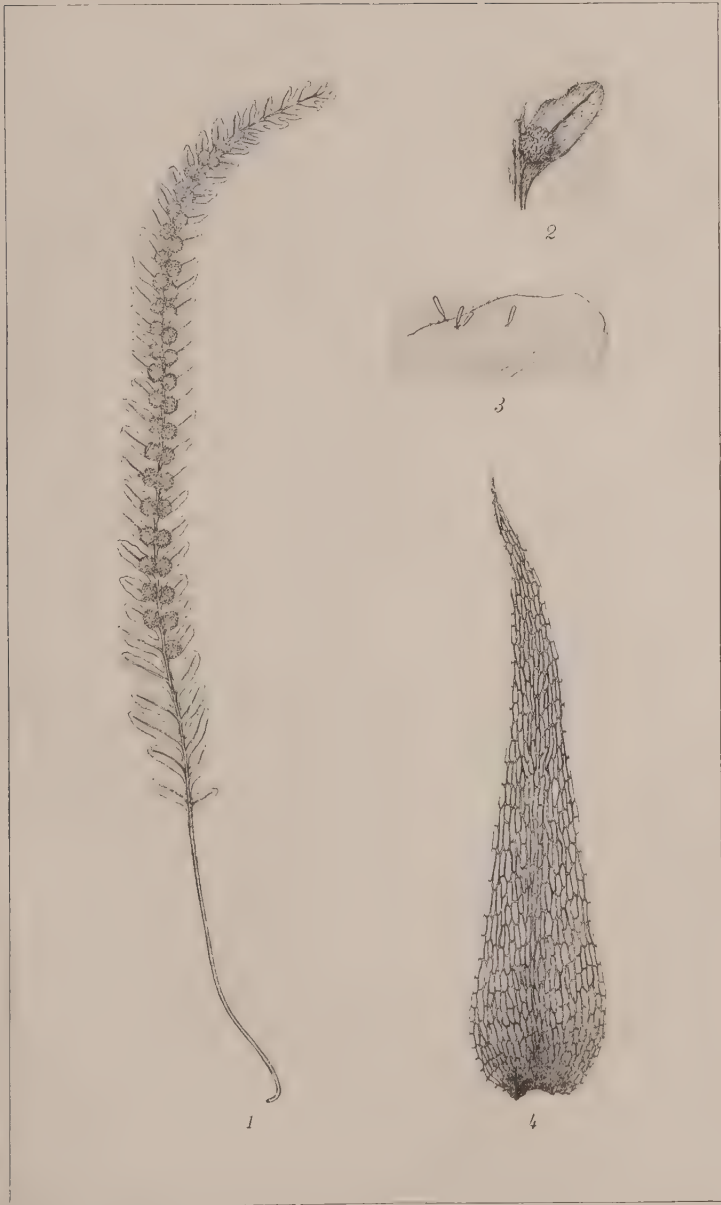
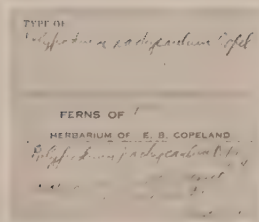
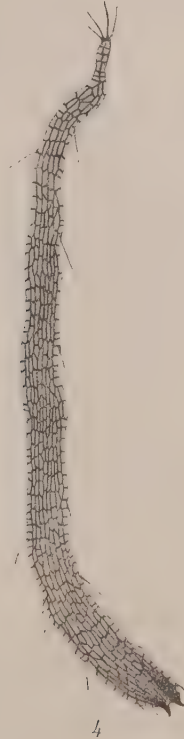
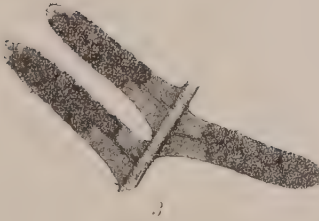


PLATE 9.



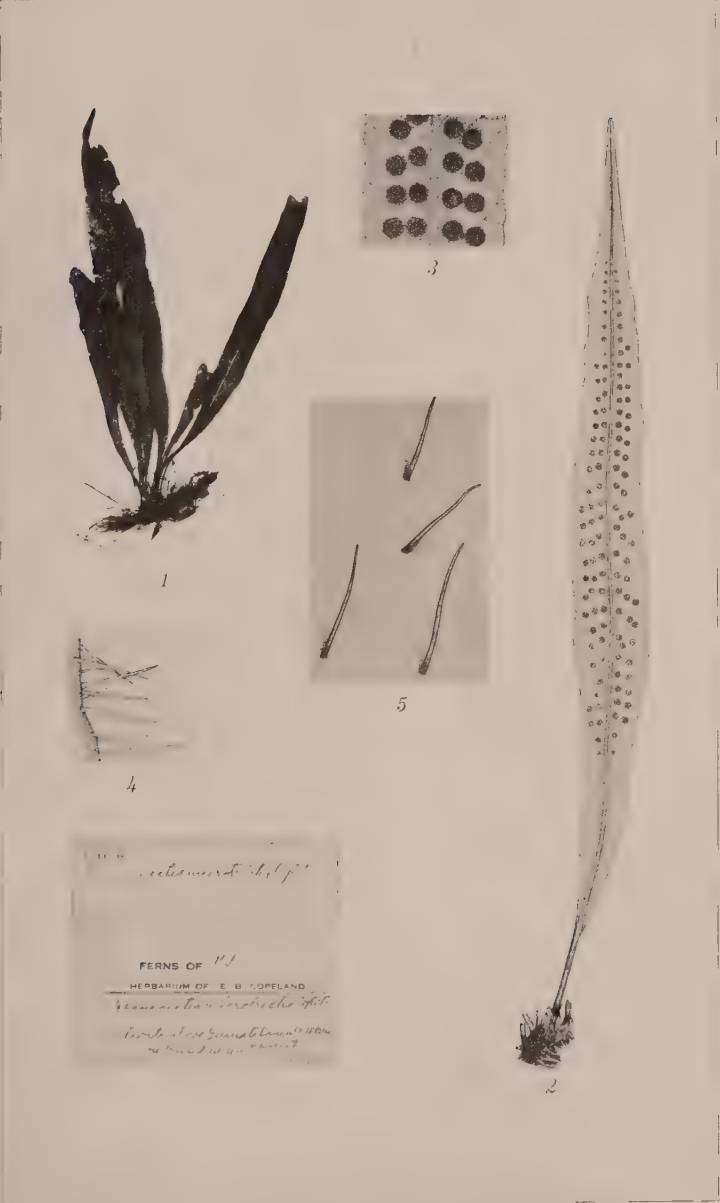


PLATE 11.





PLATE 13.



PLATE 14.

CONTROL OF PINEAPPLE MEALY-BUG WILT¹

By F. B. SERRANO²

Of the Bureau of Science, Manila

TWO PLATES

INTRODUCTION

Pineapple mealy-bug wilt is by far the most destructive malady known to affect the pineapple plant, *Ananas comosus* (Linn.) Merr., particularly Smooth Cayenne, which is considered the premier commercial variety. It is characterized by a general wilting of the plant, with or without green spotting on the leaves. It assumes a number of forms depending upon the age, the succulence, and the vigor of the plant, as well as the size and time of onset of the initial mealy-bug infestation. A large population at the onset of the initial mealy-bug infestation produces quick wilt (Plate 1, fig. 4), while a small number of insects produces slow wilt (Plate 1, fig. 4, x). The younger and the more succulent and vigorous the plant is, the quicker it succumbs to quick wilt.

Pineapple mealy-bug wilt is caused by the toxic secretion of the pineapple mealy bug, *Pseudococcus brevipes* (Ckll.).⁽⁴⁾ It is found everywhere the Smooth Cayenne pineapple is grown, causing almost complete collapse of the entire field, in several instances. While much has already been said by various investigators about its destructiveness, etc., no definite information about its control is given in any of the available literature on the subject. In view of this and of its economic importance, attempts were made immediately after its true cause was known to find ways and means to control it or at least to check its spread.

¹ This is a continuation of "Pineapple mealy-bug wilt in the Philippines," Philip. Journ. Sci. 55 (1934) 363-377.

² The writer wishes to express his thanks to the Philippine Packing Corporation for the splendid coöperation extended him in supplying practically all the material and labor used in conducting the experiments. He is also grateful to Dr. G. O. Ocfemia, of the Agricultural College, Laguna, for reading the manuscript.

HOW PINEAPPLE MEALY-BUG WILT SPREADS

Full knowledge of how the malady spreads is of prime importance in devising means of control. A more or less exhaustive investigation of the matter was therefore made, and it was ascertained that the pineapple mealy bug may be disseminated in three ways; namely, through infested plant material, through the agency of ants, and to some extent, through its own volition.

When plant material such as crowns or tops, slips, suckers, stumps, seedlings, and fruits are removed from an infested field without previous treatment for pineapple mealy-bug control, the pest may be introduced to new fields. This practice is in fact responsible for the rapid spread of the malady.

Another sure way of spreading the pest is through the aid of two species of ants, *Pheidole megacephala* (Fabr.) and *Solenopsis geminata* Fabr. var. *rufa* Jerdon, which feed on the honeydew secreted by the mealy bug and which, in return, take care of the young mealy bugs.

The pineapple mealy bug may also invade, although to a very limited extent, new pineapple plants through its own volition. It can crawl from leaf to leaf and from plant to plant. This is especially true with the gray strain or the green-spotting type⁽⁴⁾ which does not seem to like remaining very long in one spot.

SPRAYING EXPERIMENTS

The spraying experiments for the control of the pineapple mealy bug were carried out in the pineapple fields of the Philippine Packing Corporation situated at Santa Fe, Bukidnon Province, Mindanao, from January to September, 1930. That year was climatically speaking unusually dry for that locality. It was, nevertheless, favorable for the mealy bugs and, fortunately, also for spraying.

EXPERIMENT 1

Materials and methods.—To find out the best insecticide for the control of the pineapple mealy bug the efficacy and feasibility of soapsuds spray, nicotine-soap spray, and oil-emulsion spray were tested. The experiment was laid out in January, 1930, on thirty-six double rows of standard length of 4-month-old Hawaiian Smooth Cayenne variety, spaced 56 by 22 by 18 inches. The plants were uniform in size and general vigor, with more or less uniform mealy-bug infestation, but showed no signs of wilt at the time.

The block was divided into three parts of twelve rows each. The first part was treated by spraying with 2 per cent soapsuds³ rows 1 to 3 and 7 to 9 at monthly and bimonthly intervals, respectively, for four months, leaving rows 4 to 6 and 10 to 12 unsprayed as check. The second part instead was treated similarly with nicotine soap⁴ for rows 13 to 15 and 19 to 21, and with oil emulsion⁵ for rows 25 to 27 and 31 to 33, leaving the rest unsprayed as check. By means of a compressed-air spray pump (Plate 2) all of the plants except the check were sprayed one by one, each leaf thoroughly wetted, and the spray material driven between the closely appressed leaves and the heart especially, where an abundance of the mealy bugs is found.

Results.—At the close of the experiment observations on the general health and vigor of the plants were made. The results are presented in Table 1.

It is shown in Table 1, first, that the mealy-bug wilt of pineapple may be checked by spraying with either soapsuds, nicotine soap, or oil emulsion; second, that monthly application is more effective than bimonthly application; and third, that these sprays are practically the same in efficiency, soapsuds having 73.9 per cent; nicotine soap, 77.2 per cent; and oil emulsion, 83.3 per cent efficacy. The wilting of some of the sprayed plants may, perhaps, be explained by the fact that when the spraying was started several of the plants had already heavy mealy-bug infestation, although no signs of wilt were visible at the time. Had the spraying been started earlier or before the mealy bugs got well established, better results might have been obtained.

An after-effect of the treatment noticed is the scorching of the leaves sprayed with either nicotine soap or oil emulsion. Such harmful effect is, however, much more pronounced in the latter, in many instances causing decay of the heart or terminal

³ Soap solution was prepared by dissolving 378.5 grams of laundry soap (Señorita) in water to make 19 liters of 2 per cent solution.

⁴ Nicotine-soap was prepared by mixing 15 liters of 2 per cent soapsuds with 4 liters of concentrated tobacco decoction.

⁵ Oil emulsion was prepared by emulsifying a mixture of 378.5 cc rope oil and 378.5 cc water, in which 378.5 grams brown pottery clay had been slaked. Emulsification is done by passing the mixture through a spray pump several times, then adding to it enough water to make 19 liters of 2 per cent emulsion. The mixture is repassed through the pump once more before using.

bud of the plant. Unfortunately the injury does not become manifest until after a month or so. The decay of the heart induces the plant to branch off in the form of five or more suckers, the production of which delays the maturing of the crop.

TABLE 1.—Showing comparative efficacy of soapsuds, nicotine soap, and oil emulsion for the control of pineapple mealy-bug wilt.

Rows.	Treatment.	Spraying intervals.	Observations.		Ef- ficiency.
			Healthy.	Wilting.	
1- 3	Soapsuds.....	Monthly.....	1,200	60	Per cent. 80.0
4- 6	Check.....		960	300	
7- 9	Soapsuds.....	Bimonthly.....	1,165	95	67.7
10-12	Check.....		966	294	
Average.....					73.9
13-15	Nicotine soap.....	Monthly.....	1,215	45	84.5
16-18	Check.....		969	291	
19-21	Nicotine soap.....	Bimonthly.....	1,167	93	69.9
22-24	Check.....		951	309	
Average.....					77.2
25-27	Oil emulsion.....	Monthly.....	1,221	39	87.0
28-30	Check.....		960	300	
31-33	Oil emulsion.....	Bimonthly.....	1,200	60	79.6
34-34	Check.....		966	294	
Average.....					83.3

EXPERIMENT 2

Owing to the cheapness, handiness, availability, and especially the efficacy of soapsuds spray, which proved to be practically as high as that of either nicotine soap or oil emulsion, it was decided to ascertain the best way to attain the most satisfactory results with it. Laboratory tests (the inclusion of which is deemed unnecessary) clearly showed that of the various brands of laundry soap, Señorita is the one that compares most favorably with Chinese Yellow in efficacy. Chinese White and Lenox are practically the same. Because Señorita soap has a more stable and more reliable consistency than Chinese Yellow, it was chosen for all subsequent experiments of this series as well as others in which soap is the main constituent of the spray solution.

Materials and methods.—This experiment was laid out in April, 1930, on fifty-four double rows (56 by 22 by 18 inches) of 4-month-old Hawaiian Smooth Cayenne plants in the pineapple fields of the Philippine Packing Corporation, at Santa Fe, Bukidnon, showing uniformity in general stand and vigor, as

well as in the distribution and extent of the pineapple mealy-bug infestation. Soapsuds in three dilutions, 1, 1.5, and 2 per cent, were employed in three different series; that is, as plain soapsuds, as soapsuds with brown pottery clay, and as hot soapsuds. Solutions of the various concentrations were prepared from a 10 per cent stock solution.

Starting with plain soapsuds, plants of rows 1 to 3 were sprayed thoroughly, one by one, with 1 per cent solution; rows 7 to 9, with 1.5 per cent; and rows 13 to 15, with 2 per cent, leaving rows 4 to 6, 10 to 12, and 16 to 18 unsprayed as check.

With the compressed-air pump spraying was done monthly for from two to five months, depending on the prevalence of the mealy bugs. The remaining rows were treated in like manner but with soapsuds containing 0.2 per cent brown pottery clay, for rows 19 to 21, 25 to 27, and 31 to 33, and plain soapsuds heated to from 45° to 50° C. for rows 37 to 39, 43 to 45, and 49 to 51, while the other rows, 22 to 24, 28 to 30, 34 to 36, 40 to 42, 46 to 48, and 52 to 54, remained unsprayed as check.

Results.—The observations made at the close of the experiment are presented in Table 2.

TABLE 2.—Showing increase in the relative efficacy of soapsuds of different concentrations caused by the addition of clay and by heating.

Rows.	Treatment.	Concentration.	Applications.	Observations.		Efficiency.
				Healthy.	Wilted.	
		<i>Per cent.</i>				<i>Per cent.</i>
1-3	Soapsuds, plain.....	1.0	5	1,180	80	72.9
4-6	Check.....			965	295	
7-9	Soapsuds, plain.....	1.5	4	1,197	68	79.0
10-12	Check.....			959	301	
13-15	Soapsuds, plain.....	2.0	3	1,202	58	80.4
16-18	Check.....			963	297	
Average.....						77.5
19-21	Soapsuds plus 0.2 per cent clay.....	1.0	4	1,193	67	77.5
22-24	Check.....			962	298	
25-27	Soapsuds plus 0.2 per cent clay.....	1.5	3	1,200	60	80.0
28-30	Check.....			960	300	
31-33	Soapsuds plus 0.2 per cent clay.....	2.0	2	1,200	60	79.6
34-36	Check.....			966	294	
Average.....						79.0
37-39	Soapsuds, 45-50 °C.....	1.0	3	1,195	65	77.6
40-42	Check.....			970	290	
43-45	Soapsuds, 45-50 °C.....	1.5	2	1,200	60	79.9
46-48	Check.....			962	298	
49-51	Soapsuds, 45-50 °C.....	2.0	2	1,202	58	80.7
52-54	Check.....			960	300	
Average.....						79.4

Table 2 shows that the optimum concentration of soapsuds for the control of pineapple mealy-bug wilt seems to lie between 1.5 and 2 per cent, and that the addition of 0.2 per cent brown pottery clay or heating the solution to from 45° to 54° C. renders the soapsuds more effective. These facts are indicated by the number of applications needed by each treatment, by the number of healthy and diseased plants, and by the average percentage of efficiency. As in the first experiment it was also noted that the plants that came out diseased in the sprayed rows are those which have had more or less heavy mealy-bug infestation, although they showed no signs of wilt when the experiment was started.

In field practice one of the things tried to make the spray more effective and giving satisfactory results was to brush the mealy bugs off with a long-handled brush (Plate 2), simultaneously with spraying. High pressure was also found to contribute to the effectiveness of the spray. The higher the pressure at which the spray is delivered the quicker and the surer the mealy bugs are stripped of their woolly and waxy covering, hence the quicker they succumb to the treatment.

DIPPING EXPERIMENTS

While spraying is necessary for the control of pineapple mealy-bug wilt once the pest has gained foothold in the field, greater emphasis must be placed on using only mealy-bug-free plant material (suckers, slips, crowns, etc.), particularly in starting new plantations. This was clearly demonstrated by the check plants used in the infestation experiments.⁽⁴⁾ Whenever possible plant material should be obtained only from mealy-bug-free fields. If the plantations are infested, however, efforts should be made to select the plant material from mealy-bug-free individuals. Otherwise effective treatment of some kind, like dipping, must be resorted to before setting out the plants.

As it has been shown conclusively in the writer's earlier article⁽⁴⁾ that pineapple mealy-bug wilt is caused by the pineapple mealy bug, *Pseudococcus brevipes* (Ckll.), it is axiomatic that the exclusion of the insect will prevent the malady. It was felt to be of prime importance, therefore, to search for an effective means by which the plant material could be freed from the mealy bugs, granting that such plant material was infested. In the preceding spraying experiments it was revealed that soapsuds are just as good as, if not better than, either nico-

tine soap or oil emulsion for the control of the pineapple mealy bug, because of their handiness, cheapness, feasibility, stability, and high order of efficacy. The following experiments, started November 1, 1930, in Santa Fe, Bukidnon Province, were designed to explore the suitability of soapsuds as a dipping solution.

EXPERIMENT 3

Materials and methods.—Three different concentrations of soapsuds were prepared; namely, 44 liters of 1 per cent, 44 liters of 1.5 per cent, and 44 liters of 2 per cent; each solution was divided into four equal parts and kept in empty gasoline cans. Stumps of wilting 8-month-old Smooth Cayenne plants showing mealy bugs in abundance were collected and trimmed. Nine of such stumps were immersed in the first solution; three of them were "fished out" after 10 minutes, three after 20 minutes, and the remaining three after 30 minutes, and each batch was placed in a separate, properly labelled, enameled pan with the lips lined with Tanglefoot preparation to prevent ants from taking away any mealy bugs that might survive the treatment. The same number of stumps were treated similarly in the second solution, another batch in the third solution, and still another in the fourth, the latter two solutions being kept at a temperature ranging between 54° and 55° C. during the treatment. This completes the tests in the first series of 1 per cent solution. Tests on the remaining two series of 1.5 per cent and 2 per cent solutions were carried out in exactly the same manner and with the same number and kind of stumps infested with an abundance of pineapple mealy bugs. Care was taken to make the conditions of the experiment in all essentials as nearly identical as possible throughout the whole series.

Results.—The following day the stumps of the three series were examined minutely, one by one, with the help of a binocular for the mealy bugs present, dead or alive. The results are given in Table 3.

Table 3 shows that for the control of pineapple mealy-bug wilt soapsuds are more effective with pottery clay than without, and that their efficacy is increased by more than twice when the solution is heated to and maintained at a temperature of 54° to 55° C. during the treatment. It is also shown that at room temperature 1 per cent is as ineffective as either 1.5 per cent or 2 per cent; but when used at 54° to 55° C. they are equally

TABLE 3.—The number of living and the number and percentage of dead mealy bugs found on each plant material after dipping in unheated and hot soap solution of different concentrations with and without the addition of pottery clay.

Solution.	Concen- tration.	Tem- perature.	Duration of exposure in minutes.										Average efficacy.
			10			20			30				
			Alive.	Dead.	Efficacy.	Alive.	Dead.	Efficacy.	Alive.	Dead.	Efficacy.		
	Per cent.	°C.			Per cent.			Per cent.			Per cent.		
Soapsuds, plain.....	1.0	26-27	545	165	23.2	801	384	32.4	490	370	43.0	32.8	
Soapsuds plus 0.2 per cent clay.....	1.0	26-27	490	268	35.3	472	326	40.8	288	376	56.6	44.2	
Soapsuds, plain.....	1.0	54-55	6	534	83.8	0	540	100.0	0	330	100.0	96.3	
Soapsuds plus 0.2 per cent clay.....	1.0	54-55	0	652	100.0	0	504	100.0	0	589	100.0	100.0	
Soapsuds, plain.....	1.5	26-27	574	222	37.9	491	391	44.3	285	312	52.2	41.4	
Soapsuds plus 0.2 per cent clay.....	1.5	26-27	440	274	38.3	366	364	50.5	240	420	63.6	50.8	
Soapsuds, plain.....	1.5	54-55	10	579	98.3	0	490	100.0	0	712	100.0	99.4	
Soapsuds plus 0.2 per cent clay.....	1.5	54-55	0	712	100.0	0	489	100.0	0	605	100.0	100.0	
Soapsuds, plain.....	2.0	26-27	405	262	37.7	584	418	41.7	286	384	57.3	45.6	
Soapsuds plus 0.2 per cent clay.....	2.0	26-27	496	336	40.3	432	332	46.9	204	432	67.9	51.7	
Soapsuds, plain.....	2.0	54-55	5	657	99.2	0	620	100.0	0	718	100.0	99.7	
Soapsuds plus 0.2 per cent clay.....	2.0	54-55	0	543	100.0	0	477	100.0	0	490	100.0	100.0	

effective, rendering mealy-bug-infested stumps absolutely free from the infestation in ten minutes if 0.2 per cent pottery clay is added to the solution, and in twenty minutes if no pottery clay is added.

Another point brought out by these results is that in spraying 1.5 per cent soapsuds gives 100 per cent killing power or efficiency, whereas preparations at even higher concentrations are practically useless as dipping solutions unless applied hot. In order, therefore, that a spraying solution of given concentration may be effective as a dipping solution it must be used hot. It is pertinent, perhaps, to mention in this connection that heat alone at a temperature of 54° to 55° C. does not kill the mealy bugs; when infested plant specimens were immersed in tap water at the same temperature for the same duration, none of the mealy bugs was killed.

EXPERIMENT 4

It has been amply demonstrated in the preceding experiments that soapsuds of any reasonable concentration are not sufficiently effective as a dipping solution for the control of the pineapple mealy bug unless used hot. It was desirable, therefore, to find out the best temperature and time exposure for each type of pineapple plant material.

Materials and methods.—Ninety liters of 1.5 per cent soapsuds were prepared and divided equally in six empty gasoline cans numbered from 1 to 6. Solution 1 was heated, and upon reaching the temperature of 39° to 40° C., at which it was maintained, nine trimmed stumps of 8-month-old wilting Smooth Cayenne plants were immersed in it; three of them were "fished out" after 40 minutes, three after 50 minutes, and the last three after 60 minutes, and each set was placed separately in an enameled basin with lips lined with Tanglefoot preparation to prevent ants from taking away any mealy bug that might survive the treatment. After this, three batches consisting of nine suckers weighing about 150 grams each, nine slips of about 100 grams each, and nine crowns of about 50 grams each were treated similarly, one by one, while the temperature of the soap solution was maintained at 30° to 40° C. The same kinds and number of plant materials were treated, in an identical manner, but with one series at 42° to 43° C., one at 45° to 46° C., one at 48° to 49° C., one at 51° to 52° C., and another at 54° to 55° C.

TABLE 4.—The number of living and the number and percentage of dead mealy bugs found on each plant material and the degree of scorching of each kind of plant material after immersion in 1.5 per cent soap solution at different temperatures and exposures.

Group.	Temperature of solution.	Exposure.	Observations.					
			Stumps.			Suckers, $\pm$ 150 grams each.	Slips, $\pm$ 100 grams each.	Crowns, $\pm$ 50 grams each.
			Alive.	Dead.	Efficacy.			
	$^{\circ}\text{C.}$	Min.			Per cent.			
1	39-40	40	18	1,720	97.8	Normal	Normal	Normal.
	39-40	50	16	1,940	99.2	do.	do.	Do.
	39-40	60	0	1,595	100.0	do.	do.	Do.
2	42-43	40	9	1,416	99.3	do.	do.	Do.
	42-43	45	6	1,992	99.7	do.	do.	Do.
	42-43	50	0	1,566	100.0	do.	do.	Do.
3	45-46	30	14	1,445	99.0	do.	do.	Slightly scorched.
	45-46	35	0	1,427	100.0	do.	do.	Do.
	45-46	40	0	1,507	100.0	do.	do.	Do.
4	48-49	15	16	1,501	98.8	do.	Severely scorched.	Severely scorched
	48-49	20	0	1,776	100.0	do.	do.	Do.
	48-49	25	0	1,522	100.0	do.	do.	Do.
5	51-52	10	17	1,129	98.5	Severely scorched.	do.	Do.
	51-52	15	0	1,577	100.0	do.	do.	Do.
	51-52	20	0	1,757	100.0	do.	do.	Do.
6	54-55	5	13	1,220	98.9	do.	do.	Do.
	54-55	10	0	1,566	100.0	do.	do.	Do.
	54-55	15	0	1,518	100.0	do.	do.	Do.

Results.—The following day all of the stumps were minutely examined, one by one, under a binocular, and the mortality of the mealy bugs present on each noted. This having been completed, all of the shoots and crowns were gone over, group by group, the next day, for any sign of scorching that the treatment might have produced thereon, and classified as normal, slightly scorched, or severely scorched, as the case might be. The results are given in Table 4.

It is shown in Table 4 that a 100 per cent killing of the pineapple mealy bugs can be effected by soaking the plant material 60 minutes in soapsuds of 1.5 per cent concentration with 0.2 per cent brown pottery clay at a temperature of 39° to 40° C.; 50 minutes at 42° to 43° C.; 35 minutes at 45° to 46° C.; 20 minutes at 48° to 49° C.; 15 minutes at 51° to 52°

C., and 10 minutes at 54° to 55° C. It is also shown that suckers weighing about 150 grams each can withstand soaking for 20 minutes at 48° to 49° C. without danger of becoming scorched; slips weighing about 100 grams each, for 35 minutes at 45° to 46° C.; and crowns weighing about 50 grams each, for 50 minutes at 42° to 43° C. It is quite evident from these results that pineapple plant material of all types may be freed from mealy-bug infestation by soaking in hot 1.5 per cent soap solution, in the following order:

Stumps, 15 minutes at 51° to 52° C.

Suckers, 150 grams, 20 minutes at 48° to 49° C.

Slips, 100 grams, 35 minutes at 45° to 46° C.

Crowns, 50 grams, 50 minutes at 42° to 43° C.

Seedlings, small, 60 minutes at 39° to 40° C.

The results of both spraying and dipping experiments as presented in the preceding tabulations become more significant in the light of Carter's⁽¹⁾ revelation of the results of his laboratory and field tests in dipping and spraying for mealy-bug control in Hawaii, stating among other things, that various commercial oil emulsions provide a satisfactory means of control, although the susceptibility of the plants to scorching imposes severe restrictions on their use. The writer found this to be so when comparison between the efficiency of soapsuds, nicotine soap, and oil emulsion for the same purpose was made.

VACUUM FUMIGATION

Another possibility to render the plant material free from the mealy bugs is vacuum fumigation. That this possibility merits consideration is shown by the report of Hagan⁽³⁾ in Hawaii, that vacuum fumigation with hydrocyanic acid gas at the rate of 10 ounces sodium cyanide to 1,000 cubic feet of space for one to one and one-half hours and 28 inches of vacuum at the start, gave satisfactory results. Similar treatment with either carbon bisulphide or chlorpicrin resulted, however, in great injury to the plant material.

SCOUTING

Scouting to locate the focus of infestation is of fundamental importance and should go hand-in-hand with spraying. In fact it should precede spraying. This is especially necessary when plants are still young and the mealy bugs not yet well established. Its usefulness cannot be overemphasized considering the

fact that the malady does not become conspicuous until after the infestation has gone too far to respond to drastic and costly treatment. An early discovery of its occurrence is of fundamental value. This can be effected by proper scouting under trained personnel at least once a month.

NATURAL ENEMIES AND PREDATORS

The pineapple mealy bug has a number of natural enemies and predators, such as the brown lacewing sympherobid, *Sympherobius augustus*; the ladybird beetle, *Cryptolaemus montrouzieri* Muls.; *Lobodiplosis pseudococchi* Felt;⁽²⁾ and a grasshopper, *Conocephalus saltator* Sauss. The first two were introduced from Hawaii by the Philippine Packing Corporation, in 1930, in Bukidnon Province, Mindanao. Efforts should be made to encourage the rapid multiplication and spread of such benefactors, for under ordinary conditions they should be able to hold the mealy bugs under control.

ANT CONTROL

While there are natural enemies and predators attacking the pineapple mealy bug, there are also on the other hand insects protecting it. Two species of ants, *Pheidole megacephala* (Fabr.) and *Solenopsis geminata* Fabr. var. *rufa* Jerdon are known to do this. They feed on the honeydew secreted by the mealy bug whose young they protect in return from enemies. Keeping these ants under check will therefore not only enhance the activities of the natural enemies and predators of the pineapple mealy bug but will also adversely affect the general vigor and fecundity of the mealy bug itself.

Controlling these ants, particularly the red variety, *Solenopsis geminata* Fabr. var. *rufa* Jerdon, is not an easy matter. However, clean culture and surface mulching by harrowing the ground of the plantation, whenever possible, may help in driving them away. Simple soapsuds spray as employed for the mealy bug treatment is effective and cheap enough to use for the black ant, *Pheidole megacephala* (Fabr.), which may be killed in its dugouts by pouring the solution into the holes. The red ant, on the other hand, never appears greatly concerned when treated with any of the three insecticides which proved destructive to the mealy bug. Fumigants like chlorpicrin, carbon bisulphide, and hydrocyanic acid gas may prove effective in the control of both ants, and their applicability should be carefully and thoroughly studied.

BORDER PLANTING

On the assumption that new fields planted to mealy-bug-free seeds are adjacent to infested old fields, border planting as supplementary means of checking the malady seems advisable. This would tend to slow down the influx of the mealy bugs migrating from a mealy-bug-laden field, and to localize infestation, thereby facilitating spraying operations. Border planting to be effective must consist of a bed of at least four rows and the plants must be as succulent and vigorous as those in the main plantation so as to provide enough inducement for the mealy bug to remain. These conditions are necessary for detaining the insect in the border planting and effectively checking its advance.

SUMMARY

1. It has been observed that the pineapple mealy-bug wilt may be disseminated in a number of ways; namely, through infested plant material, such as suckers, slips, crowns, etc., through ants, and through the mealy bug's own volition.

2. Field tests have shown that the pineapple mealy-bug wilt may be controlled by spraying about once a month with 1.5 per cent soap solution. The addition of pottery clay (about 0.2 per cent), preferably the brown type, renders the solution more effective.

3. Nicotine-soap solution and oil emulsion have proved to be practically as effective as soapsuds, if not more so, in killing the pineapple mealy bug. Owing, however, to their scorching effect on plants, which is quite serious, particularly in the case of oil emulsions, their application is considered rather precarious. Hence, soap solution is considered preferable.

4. Laboratory tests have shown that of the different brands of laundry soap tried the Chinese Yellow has the highest efficiency, followed closely by the Señorita. The Chinese White and the Lenox are practically of the same strength.

5. For dipping purposes soapsuds at any reasonable concentration are practically worthless unless used hot, as follows: Stumps, 15 minutes at 51° to 52° C.; suckers, about 150 grams, 20 minutes at 48° to 49° C.; slips, about 100 grams, 35 minutes at 45° to 46° C.; crowns, about 50 grams, 50 minutes at 42° to 43° C.; seedlings, 60 minutes at 39° to 40° C. Complete freedom from the pineapple mealy bug is secured by dipping infested plant material in 1.5 per cent soap solution at these temperatures and corresponding time exposures. One-hundred-ninety-liter

barrels or large vats equipped with heaters may be used for this purpose.

6. As in spraying, the addition of pottery clay (about 0.2 per cent), preferably the brown type, renders the dipping solution more effective, while heating to 45° to 50° C. increases its efficacy more than twice.

7. Proper scouting to locate the focus of infestation is necessary for successful spraying. It is especially needed in young plantations where the mealy-bug colonies may actually become established rapidly although no outward manifestations of the malady are yet shown.

8. Quick reproduction and spread of the pineapple mealy-bug's natural enemies and predators—such as, *Sympherobius augustus*, *Cryptolaemus montrouzieri* Muls., *Lobodiplosis pseudococci* Felt, and *Conocephalus saltator* Sauss.—should be studied and the results obtained therefrom disseminated among pineapple growers.

9. Keeping under check the ants *Pheidole megacephala* (Fabr.) and *Solenopsis geminata* Fabr. var. *rufa* Jerdon, which are in symbiotic association with the pineapple mealy bug, *Pseudococcus brevipes* (Ckll.), will materially help in keeping the malady under control.

10. In starting new plantations in districts where the malady is more or less well established border planting is a necessary precaution, particularly when ants are abundant.

11. The need for using nothing but mealy-bug-free plant material in opening new plantations cannot be overemphasized. This may be accomplished by either selecting plant material from mealy-bug-free fields or properly treating the mealy-bug-infested plant material prior to planting.

LITERATURE CITED

1. CARTER, W. The use of insecticides on pineapple plants in Hawaii. *Journ. Econ. Ent.* 24 (1931) 1233-1242.
2. FELT, E. P. A new enemy (*Lobodiplosis pseudococci* sp. nov.) of the pineapple mealy-bug [*Pseudococcus brevipes* (Ckll.), in Hawaii] and a list of gall midge enemies of mealy bugs. *Journ. N. Y. Ent. Soc.* 61 (1933) 119-123.
3. HAGAN, H. R. Vacuum fumigation of pineapple planting material. *Journ. Econ. Ent.* 24 (1931) 1002-1012.
4. SERRANO, F. B. Pineapple mealy-bug wilt in the Philippines. *Philip. Journ. Sci.* 55 (1934) 363-377.

ILLUSTRATIONS

PLATE 1

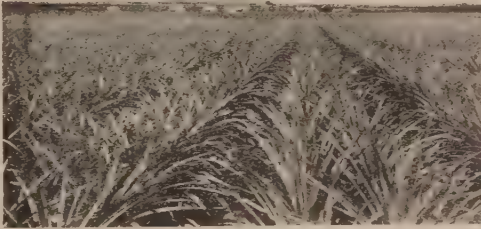
- FIG. 1. Three-month-old Smooth Cayenne plantation free from wilt. Planting material was treated with dipping soap solution before planting.
2. Same as fig. 1, eighth month; the plant is still free from wilt.
 3. Same as figs. 1 and 2, thirteenth month; the plant is still free from wilt.
 4. Thirteen-month-old Smooth Cayenne plantation on the verge of collapse due to wilt. Plant material was not treated for mealy-bug control before planting. Plants in the foreground are victims of quick wilt, while those marked x are suffering from slow wilt. All figures about $\times 0.02$. (All photographs by the author.)

PLATE 2

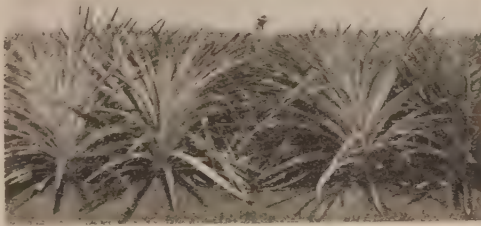
Compressed-air spray pump, with a handmade long-handled brush on the left side; about $\times 0.2$. (Photograph by C. S. Angbengco.)



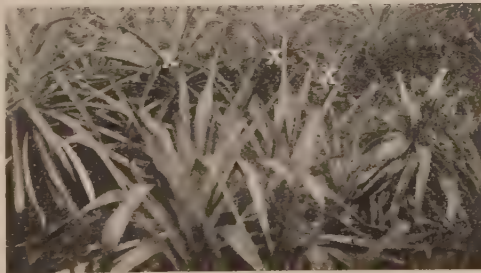
1



2



3



4

PLATE 1.



PLATE 2.

A MORPHOLOGICAL STUDY OF A NYMPHOMYIID FLY ¹

By MASAOKI TOKUNAGA

Assistant Professor of Entomology, Kyoto Imperial University, Japan

FIVE PLATES AND SIX TEXT FIGURES

INTRODUCTION

The remarkable dipterous insect *Nymphomyia alba* Tokunaga, the subject of this investigation, was first collected in March, 1932, by myself along a torrential stream at Kibune, Kyoto (200 to 420 meters in altitude), a locality famous for its rich insect fauna and also known as the habitat of other peculiar insects; such as, *Epiophlebia suprestes* Salys (Odonata), *Deuterophlebia* sp. (Diptera), *Galloisiana nipponensis* Caudell and King (Orthoptera), *Lyeæropsis sugitani* Matsumura (Lepidoptera), etc. In December, 1932, a brief report on this new species, from the taxonomic viewpoint, was published in *Annotationes Zoologicae Japonenses*, the substance of this paper having been previously presented at the Eighth Annual Meeting of the Japanese Zoological Society held in October, 1932, at Taihoku, Formosa.

The present paper deals with the external morphology of this interesting form and gives, in addition to full descriptions of the structures, discussions on the homology of the sclerotization, concluding with a suggestion on the phylogenetic position of this fly among the dipterous insects.

Most of the nymphomyiid flies examined were collected in the fall of 1932 at Kibune, and preserved in 70 per cent alcohol after fixing in Carnoy's fluid. Living and dried material, and also that directly preserved in 70 per cent alcohol, as well as fixed material, was freely used in this study. For supplementary purposes various dipterous and other insects in the university collection were also examined. Dissections were carried out under a binocular microscope by means of steel and glass needles. When the material needed softening, it was treated in 5 per cent potassium hydroxide. Ziehl's carbolic fuchsin or

¹ Contribution from the entomological laboratory, Kyoto Imperial University, Japan, No. 36.

Mann's methyl-blue-eosin was used for the staining of the dissected pieces. Fine dissected pieces were observed under high magnification after mounting in glycerine-alcohol or cedar oil.

This investigation was undertaken under the direction of Prof. Dr. Hachiro Yuasa. For his invaluable assistance, which made this study possible, I desire to express my hearty thanks.

MORPHOLOGICAL DESCRIPTION

The morphological terminology used in this paper is mainly adopted from that of MacGillivray (1923) and of Tokunaga (1930 and 1932), supplemented from that of various modern writers.

In its general features this fly resembles a certain caddice-fly larva rather than any known dipterous insect. It is small and delicate, measuring about 2.3 millimeters in length, and is white in life. The important characteristic structures of this fly may be briefly described as follows:

1. The head is prognathous in type, with a very large occipital foramen, and elongated cephalad, forming a snoutlike projection. The mouth opening is located in the characteristic pocketlike mouth cavity and all of the mouth parts are almost completely atrophied. The compound eyes are contiguous on the ventral side. The two ocelli are located on the lateral sides of the head capsule and are very large. The antennæ are of brachycerous type characterized by the presence of the inter-segmental sensillæ.

2. The thorax is elongated and cylindrical. The pronotum is completely subdivided into two, paired, lateral halves on the middorsal line, and the prosternum is represented by a very large, undivided, primary sternum to which a pair of the laterosternites has probably united. The mesopostscutellum is extremely developed. The mesopleura are small and membranous, and the mesosternum is very large, being divided into the presternum and the basisterno-sternellum. The metanotum is atrophied, while the metasternum is very large and represented only by the basisterno-sternellum, the presternum being lost. Generally the development of the endoskeletons is very poor.

3. The wings are very narrow, cuneiform, with very long marginal setæ and a well-developed ambient vein. The veins are very few and obscure. The squama and the alula are also greatly reduced. The halteres are normal in structure, but their basal sclerites are extremely reduced.

4. The three pairs of legs are separated widely from each other, and the forelegs are articulated on the lateral side. The trochantin is atrophied. All the legs are provided with elongated coxæ and trochanters, and each coxa is provided with a basicoxal suture. Femora and tibiæ are subdivided into the proximal and distal regions by membranous rings. The claws and their accessory structures are simple. The empodium is slender and elongated. The calcanea is slender and squamous. The planta auxiliæ and pulvilli are wanting.

5. The differentiation of the pregenital segments is very slight in both sexes. The eighth abdominal segment in each sex is provided with special paratergal projections. The genital structures are exposed, and in neither sex of the concealed or telescopic type. The cerci of each sex are large and prominent. The postgenital segments are greatly reduced and uniformly fused with each other. The abdominal spiracles are all wanting.

THE HEAD

The head capsule of this fly (text fig. 1 and Plate 1, figs. 1 to 4) is quite unique both in shape and structure. The head is small, conical, elongated cephalad forming a snoutlike projection, and cephaloventrad, a labiumlike projection. The sclerites of the head capsule are fused with each other, forming a common capsule, which is entirely covered with a fine pubescence and somewhat setigerous with slender setæ. The sutures of the head are almost atrophied except for a shallow and incomplete suture on the caudodorsal region. This is a part of the epicranial stem (*es*). The occipital foramen (*of*) is very large, slightly smaller than the width of the head, round, without distinct odontoideæ but uniformly thickened along the margin. The endoskeletons (tentorium) of the head (supratentoria, pretentoria, and metatentoria) and tentorinæ (supratentorinæ, pretentorinæ, and metatentorinæ) are all wanting. Thus, in this species the muscles of the head are directly attached to the cuticular dermis without the intermediation of the chitinized tendons.

The compound eyes (*ce*) are subequal in size and shape in both sexes, oval in shape in the lateral aspect, without velutinous hairs on the surface, contiguous on the ventral side but widely separated on the dorsal. The distance between them is two-thirds the vertical length of an eye. The facets of the eyes are biconvex and granulose in appearance; there are about forty on each eye. The oculata (*ol*) is large, thickened, dark,

somewhat broader on the ventral side, and with a fine pubescence on its ectomarginal surface. On the midventral side the basal parts of the paired oculatæ are completely fused with each other, but their distal marginal parts are widely separated, so as to appear T-shaped in cross section at this point. The ocelli (*oc*) are very large, paired, present laterally or caudad of the compound eyes, or on the widest region of the head capsule; each ocellus consists of a common hyaline exocuticula and a biconvex, glassily hyaline, independent cuticular lens under which a variable amount of pigmental material is arranged in masses. The dorsomedian ocellus is wanting.

The antennæ are short, 5-segmented, and brachycerous in type in both sexes, located very near to each other on the dorsal side of the base of the snoutlike projection (*sn*) or cephalad of the compound eyes, but independently inserted in the small anta-coriæ under a small common visorlike projection. This blunt structure (*vr*) is a mere projection of the head capsule and has no homologous relation with the ptilinum of the higher Diptera. The antennaria is completely fused with the common head capsule and not visible as an independent sclerite. The basal segment, scape (*sp*), is pyriform and entirely covered with a fine pubescence, with several (usually five) small, soft, slender setæ on the distal margin. The proximal part of this segment is narrow, and this margin is thickly chitinated but without distinct antartis. The second segment, or pedicel (*p*), is somewhat smaller than the scape, and spherical; it is also covered with a fine pubescence on the entire surface and with minute hyaline sensillæ on the distal half but without setæ, and articulated to the scape by a broad coria. The third segment (β_1), proximal segment of the flagellum, is rather more membranous than the other segments; it is very large, about 1.5 times as long as the preceding two segments taken together, somewhat spoon-shaped and flattened, entirely covered with a very minute pubescence, with minute sensillæ, but without verticils, ordinary setæ. The remaining two segments of the flagellum are very minute and completely bare, not membranous, but thickened and slightly brown under transmitted light. The proximal of these two segments (β_2) is cylindrical, subequal in length to its width, while the terminal one (β_3) is elongated, conical, somewhat needlelike, and three or four times as long as the penultimate segment. Between the distal two segments of the flagellum are three clavate, hyaline, interseg-

mental sensillæ (*is*). These are very difficult to detect as they are quite hyaline.

The mouth cavity (*mc*) opens very near the ventral labium-like projection at the innermost part of the thickened cuplike concavity that is located on the proximoventral side of the snoutlike projection of the head capsule. The mouth parts are represented only by a small papilliform membranous projection (*la*), which shows a double nature, having two papillæ, and located at the entrance of the mouth cavity or on the caudal side of the pocketlike concavity. This membranous projection of the mouth parts may be taken as a reduced labial appendage like the labellum (paraglossa), judged by its location, but its exact morphological homology is not known. The other mouth parts—such as, the labrum, mandible, maxilla, maxillary palpus, hypopharynx, etc.—are completely atrophied.

The basipharynx and postpharynx are well retained in spite of the extreme reduction of the prepharynx and hypopharynx and the complete atrophy of the external trophic organs. The basipharynx (text fig. 1, *bx*) is a short canal extended obliquely, consisting of a thick dorsal wall and a thin ventral membrane, and invested with thin common ring muscles. In cross section the shape of the basipharynx is somewhat crescentic, the dorsal wall being convex ventrad and the ventral wall concave dorsad in the state of relaxation of the dilators, as usual with Diptera. The anterior end of the basipharynx is thinly membranous and directly continuous with the mouth concavity completely losing the hypopharynx and propharynx, whereas the posterior end is thickly chitinized and provided with a thicker muscular investment. The cornu, or tuberculous projection of the caudal end of the basipharynx, is not developed as highly as in the Diptera in general.

The œsophageal pump (text fig. 1, *op*) is slender, supported horizontally, as the head is prognathous in type, at the center of the head capsule, passing between the supra- and subœsophageal ganglia. The cephalic region of the œsophageal pump is comparatively large and gradually narrowed caudad. The cephalic end of the pump is expanded cephalad beyond the junction with the basipharynx, forming a saclike structure below the frontal ganglion. In the cross section (text fig. 1, *a* to *c*) the dorsal wall of the pump is thickly chitinized, while the ventral wall is almost as thick as the dorsal but not chitinized and easily flexible. The lateral wall is very delicate, membranous, and in the state

of relaxation of the dilators or of contraction of the ring muscles the œsophageal pump is folded vertically at this lateral side as shown in the series of sections *a* to *c*. Although the œsophageal pump is more or less developed throughout the Orthorrhapha Diptera, as pointed out by Peterson (1916), in the present fly it is somewhat different in structure from the pump in the other nematocerous flies. Generally in the Nematocera the cross

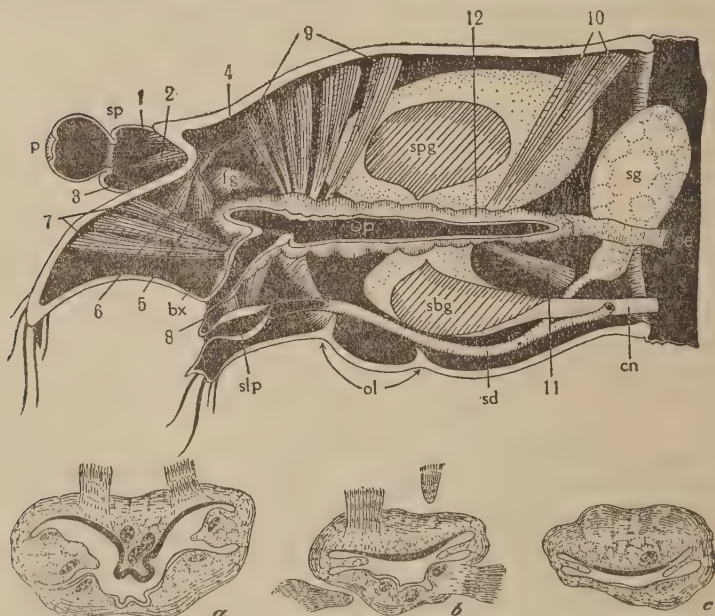


FIG. 1. Head of *Nymphomyia alba* Tokunaga. Cross sections of the basipharynx; *a*, through the attachments of the anterior dilators; *b*, through those of the posterior dilators and, *c*, of the posterior region before the œsophagus. *bx*, Basipharynx; *cn*, connective nerve; *fg*, frontal ganglion; *oe*, œsophagus; *ol*, oculata; *op*, œsophageal pump; *p*, pedicel; *sbg*, subœsophageal ganglion; *sd*, salivary duct; *sg*, salivary gland; *slp*, salivary pump; *sp*, scape; *spg*, supraœsophageal ganglion.

section of the pump is somewhat triangular and in a contracted state (relaxation of the dilators) is Y-shaped. Thus, in the Nematocera the œsophageal pump is composed of three main sides, while in the present species it consists of four main sides, as shown in the text figure.

The salivary system (text fig. 1) consists of the paired pyriform glands (*sg*), paired short ducts, unpaired long common duct (*sd*), and salivary pump (*slp*). The salivary pump rep-

resents the special dilated part of the common salivary duct and is just caudad of the salivary aperture. In cross section the pump is somewhat crescentic, consisting of the dorsal, convex (in relaxation of the pumping muscles), thickly chitinized wall, and the ventral concave membranous wall as in the basipharynx. In the longitudinal section as shown in the text figure there is a minute fold arising from the ventral wall at the posterior end of the pump, whereas there is no such projection at the anterior end and the wall at this end is continuous with the innermost wall of the mouth concavity. The posterior fold of the pump probably acts as a valve during the pumping action, preventing the backward movement of the saliva. The salivary sclerites of the hypopharynx, such as the salivæ, have not been detected and perhaps they are wanting; if present, they are very much reduced and almost atrophied. The snoutlike and labiumlike projections are merely projections of certain parts of the head capsule and provided only with a pubescence rather longer than on other parts of the head capsule; there is a pair of toothlike projections (*t*) on the distal corners of the former projection. They do not seem to have any morphological homology with the true mouth parts.

The setæ of the head are all slender but vary in length, and their arrangement on the head capsule is as follows: Six pairs of long setæ arranged transversely at the middle of the head capsule or caudad of the compound eyes, two pairs of small setæ on the dorsoproximal surface of the snoutlike projection or caudad of the blunt dorsal projection of the head capsule near the antennal base, four pairs (long and short, arranged alternately) on the meson of the dorsal surface, one pair of long setæ cephalad of the antennal base, one pair of long setæ on the lateral sides of the snoutlike projection, one pair on the distoventral part, and three pairs on the distodorsal margin of the snoutlike projection respectively, two pairs of long setæ on the caudoproximal part of the labiumlike projection or cephalad of the compound eyes, and one pair of small setæ on the caudal margin of the pocketlike mouth concavity or tip of the labiumlike projection of the head capsule. Besides the above setæ, there are two pairs of porelike sensillæ on the ventromeson of the head capsule or caudad of the compound eyes.

Muscles of the head.—On account of the extreme reduction of the external trophic organs, the development of the musculature of the head is very poor. There are only twelve different

muscles (text fig. 1), including those of the antennæ. Special apodemes and tentoria for the attachment of the muscles are not developed.

1. *Abductor of the pedicel*.—This is a comparatively small fan-shaped muscle arising from the dorsoproximal region of the inner surface of the scape and is attached to the dorsoproximal edge of the pedicel.

2. *Rotator of the pedicel*.—This slender muscle arises from the mesoproximal region of the inner surface of the scape and is inserted in the ventroproximal edge of the pedicel.

3. *Depressor of the pedicel*.—This small muscle is located on the side opposite to the abductor. It arises from the ventroproximal region of the scape and ends very near the attachment of the rotator.

4. *Depressor of the scape*.—This is a comparatively small muscle on the dorsal side. It arises from the inner surface of the vertex and ends on the dorsoproximal edge of the scape.

5. *Abductor of the scape*.—This is a short muscle on the base of the snoutlike projection. It arises from the laterodorsal wall of the head capsule, extends dorsomesad, and is inserted in the lower edge of the lateral part of the scape.

6. *Levator of the scape*.—This muscle is almost of the same size as the abductor and also situated on the base of the snoutlike projection. It arises from the laterodorsal wall of the snoutlike projection, extends dorsocaudad, and ends on the ventroproximal edge of the scape.

7. *Dilators of the basipharynx*.—These are three strong paired muscles, which arise from the dorsomesal wall (frontoclypeus) of the snoutlike projection, extend caudoventrad, and are inserted in the chitinated dorsal wall of the basipharynx through the muscular investment.

8. *Muscles of the salivary pump*.—These consist of two pairs of small muscles directly arising from the ventral membrane of the basipharynx and are attached to the central region of the chitinated dorsal wall of the salivary pump.

9. *Anterior dorsal dilators of the œsophageal pump*.—These muscles are found cephalad of the supræsoophageal ganglion, composed of five paired bands, of which each of the middle three pairs consists of two partially fused muscle bands, so that there may have been eight pairs of muscle bands originally. These dilators arise from the dorsal wall of the vertex between the compound eyes, extend ventrad, and are inserted into the dor-

socephalic part of the œsophageal pump passing through the investment of the ring muscles just caudad of the cephalic expansion of the œsophageal pump.

10. *Posterior dorsal dilators of the œsophageal pump.*—These are a pair of long strong muscles on the caudal region of the head capsule; each is composed of two partially fused muscle bands. Each muscle arises from the dorsomesal part of the occipital region, and passing under the supræœsophageal ganglion extends ventrocephalad to be attached to the dorsocaudal region of the œsophageal pump.

11. *Posterior lateral dilators of the œsophageal pump.*—These are located on the caudoventral region of the head capsule. Each of these muscles consists of one strong band, which arises from the inner surface of the postgenal region, ventrad of the ocellus, extends mesocephalad, and ends on the ventrocaudal region of the œsophageal pump very near the attachments of the posterior dorsal dilators.

12. *Ring muscles of the basipharynx and œsophageal pump.*—No specially isolated and independent sphincters have been found, such as those in *Phlebotomus*, *Simulium*, *Anopheles*, and *Culicoides*. In the case of the present fly the entire structure of the basipharynx and œsophageal pump is provided with a continuous muscular investment, which consists of a great many ring muscles. This muscular investment is especially thickened on the cephalic region of the œsophageal pump and thinnest on the basipharynx.

THE THORAX

The thorax (Plate 2, figs. 5 to 7) is scantily haired with slender setæ and entirely covered with fine pubescence, extremely elongated, cylindrical in general appearance, subequal in diameter throughout the whole length, and not produced over the head. The cervix (cc) is broad, as wide as the head itself, membranous, and without the chitinized cervepisternum and other sclerites. The spiracles of the thorax are greatly atrophied. A phragma along the caudal margin of the mesopost-scutellum is highly developed, but other phragmæ are generally obscure or obsolete.

The prothorax is small, consisting of two pairs of notal, one unpaired sternal, and one pair of small pleural sclerites, the whole structure occupying the lateral and ventral sides of the thoracic wall since the dorsal side is intruded deeply by the prolongation of the mesonotum. Of these sclerites two paired

dorsolateral sclerites are lateral halves of the antep pronotum and postpronotum, respectively, which are completely subdivided on the dorsomeson by the produced cephalic part of the mesonotum. Each half of the antep pronotum (*an*) is closely applied to the cephalic margin of the mesonotum by the intermediation of a very narrow suturelike mesocoria (*mc*) and separated from the other half of the antep pronotum of the opposite side by a wide membrane. This sclerite is characterized by the presence of several slender hairs on its dorsal region. Each half of the postpronotum (*pn*) is subtriangular, without conspicuous setæ, and partially located between the antep pronotum and mesonotum.

The ventral side of the prothorax is represented by the large, broad, subsquare prosternum (*pst*). This sternum is not divided into the presternum (sternannum), basisternum, and sternellum, and is provided with a pair of long, slender hairs on its lateral margins and a pair of blunt, thickened, triangular projections on the lateral side. These projections are the prosternacoilæ (*sc*₁), which are derived from the subcoxal element, the laterosternite, for the articulation of the forelegs. On the broad, lateral, membranous area between the pronotum and the prosternum there is a very small triangular sclerite, which is the reduced pleuron (*pp*). The whole structure of the reduced pleuron is modified into the coxacoila (*co*₁) for the articulation of the foreleg. This coila is probably derived from the episternum alone.

The mesothorax is extremely large, occupying almost the whole portion of the thorax, and especially the notum is deeply produced into the prothorax at the cephalic part and elongated into the abdomen, forming an endoskeleton (*en*₂) at the caudal part. The mesonotum is divided into three main sclerites; namely, the long scutopræscutum, the small scutellum, and the large postscutellum. The scutopræscutum (*sps*₂) is elongated and somewhat oval, formed by the complete fusion of the two sclerites, the præscutum and scutum, losing the scutal suture between them. At the cephalic end this sclerite is provided with a pair of small, incomplete, pseudosutural foveæ (*pv*, not the parapsidis). Along these foveæ in various dipterous insects setæ are usually found in variable number, but in this instance they are completely wanting. The supra-alar setal group (*sa*) of the scutopræscutum is always represented by a single small seta in both sexes. The caudal margin of the scutopræscutum is slightly intruded by the scutellum along the middorsal line (*md*). On the lateral margins of the scutopræscutum is a pair

of small blunt projections, which are the reduced medalariae (ma_2); in this instance these alariae are far removed cephalad from the wing base and not functional. Other alariae, such as the cephalariae and the caudalariae, are almost atrophied.

The scutellum (su_2) is small, situated close to the caudal margin of the scutopræscutum, and distinctly subdivided into the large median scutulis (si) and the small lateral parascutules (pc). The scutulis is somewhat pentagonal and provided with two pairs of long marginal and one pair of small median setae in both sexes. The endoskeletons of this sclerite are more developed than those of the other sclerites and consist of two kinds of phragmæ. The cephalic endoskeleton, the paraphragma (pa), is formed by the infolded cephalic margin of the meso-scutellum, and the paired lateral endoskeletons (la) are formed by the ental thickenings along the sutures between the scutulis and parascutules. The parascutulis is small, and extended laterad, forming the scutalaria (s) for the articulation of the wing. From the caudolateral angles of the scutulis the paired spirales (sl) arise, and each extends laterad along the caudal margin of the parascutulis.

The postscutellum (pl_2) is extraordinarily developed and the caudal half of the thorax, including the dorsal, lateral, and the major parts of the ventral side, is occupied by the extremely expanded postscutellum. This large postscutellum is divided by one pair of distinct sutures into the median mesascutella and lateral parascutellæ. The mesascutella (m_2) is somewhat shield-shaped and widely separated from the scutellum by the membranous coria, and its caudal one-third (en_2) is deeply infolded caudoentad into the abdomen. The surface of the mesascutella is covered with a common fine pubescence, but lacks setae, and there is a faint inverted V-shaped transversal stripe (st) on its meson, although this stripe has apparently no morphological significance. Each parascutella (ps_2) is broad, extended laterad and then ventromesad, directly demarcated by the pleurotaxis on its dorsocephalic margin, connected with the sternum by means of a narrow sternal membrane, and its cephalic prolongation completely separates the preceding epimeron (em_2) into the notepimeron (n_2) and sternepimeron (se_2) by a deep intrusion. The caudal margin of the parascutella is infolded entad and forms a narrow phragma along the round caudal margin. On the ventral side along each mesal margin of the parascutella is a small semichitinized sclerite, which is tentatively designated the parasternite (pt) of the mesothorax.

The pleural region is much narrowed by the extreme extension of the parascutella and the major parts are moreover completely reduced to membranous areas, so that the sutures are all obscure. The episternum (et_2) and epimeron (em_2) are divided by the incomplete, slightly undulated, pleural suture (p_2), which starts from the dorsal point of the pleuron, extends between the episternum and notepimeron, around the cephalic prolongation of the parascutella, and ends on the ventral margin of the pleuron near the mesocoxa fossa (c_2). The episternum is only chitinized on its ventral marginal area and its dorsal notepisternal region, and the episternal suture is completely wanting. The chitinized notepisternal region (Plate 4, fig. 13, ns) is very small and closely associated with the notepimeron (n_2) and the pleuralifera (pr), forming a projection for the articulation of the wing. The membranous sternepisternal area is provided with several indefinite folds, which are not true sutures. There is a large membranous area between the postpronotum and the mesoscutopræscutum or cephalad of the mesosternepisternum. The epimeral region (em_2) is widely separated into the notepimeron and sternepimeron by the cephalic prolongation of the parascutella (ps_2), as already mentioned. The notepimeron (n_2) is thickly chitinized, small, oval, and closely associated with the independent sclerite, the pleuralifera, and the notepisternal area on its dorsal margin and ventrocephalic margin, respectively. The sternepimeron (se_2) is located between the parascutella and the sternal membrane. The coxacoila of the mesopleuron is completely wanting in this instance.

The sternum is located on the broad membranous area, separated from the prosternum by a mesocoria at the cephalic end, and very widely separated from the metasternum by a broad metacoria. The mesosternum itself is divided into two sclerites, the presternum (prs_2) and the basisternosternellum (bs_2 and sm_2) by a distinct, membranous, secondary, transternal suture (ss). The former sclerite is cordiform, as large as the prosternum, clearly demarked, and thickly chitinized. Along the caudal margin of this sclerite is a narrow secondary phragma. On the membranous, secondary, transternal suture is a pair of small setæ; these setæ are definitely present in both sexes, although they are very difficult to detect as they are very slender. The basisternosternellum is elongated, and its demarcation is very obscure as it is reduced to a membrane but is

more or less chitinized on its cephalic and mesal parts. The cephalic part of this sclerite is provided with a pair of tiny thickened sternacoilæ (sc_2) on its lateral sides and a small membranous triangular incision (bs_2) on its meson. This small area is the basisternum proper, and the remaining large area is the sternellum proper. The midventral suture (ms) is clearly marked throughout this sclerite and more or less thickened entad, and the endoskeleton is very weakly developed along this suture.

The metathorax is very much reduced and represented only by certain parts of the pleuron and the chitinized sternum. The metanotum is completely obsolete. The pleuron is reduced to a membrane, and only a small, slightly thickened area (em_3) is found close to the abdomen or caudoventrad of the base of the haltere (h). The sternum is represented by a large, clearly demarcated sternellum (sm_3). This sclerite is similar in structure to the mesosternellum fundamentally, although it is larger, broader, and more thickly chitinized than the latter, being provided with a pair of tiny sternacoilæ (sc_3) on its cephalolateral corners, the midventral suture (ms) on its meson, and a pair of slender setæ² near the coilæ. The endoskeleton of the sternum is represented only by a narrow phragma along the caudal margin of the sternellum. The metabasisternum is completely reduced into a common membrane continuous with the ventral membranous region of the preceding thoracic segments.

THE WINGS

The wings (Plate 4, fig. 12) are snowy white in life, and at rest they are held dorsad, side by side, perpendicular to the long axis of the insect. They are extremely peculiar in structure, large for the size of the body, very much elongated, fully as long as the body or longer, and about 5.7 times as long as the widest portion of the wing itself, being about 2 to 2.5 millimeters, triangular, entirely without the anal lobe, and therefore the three margins [costal (cm), anal (am), and outer (om)] of the wing are almost straight, the ratio between them being 188 : 115 : 83. The distal angle of the wing in the male is slightly sharper than in the female. There are no macrotrichia on any part of the surface, not even on the veins, but the entire margin of the wing, except for the proximal part, is thickly

² These setæ had not been detected when the previous taxonomic report was made (1932).

fringed with very long delicate hairs, and the whole membrane is covered with minute microtrichia.

These marginal hairs are all milky white in reflected light, but pale brown under transmitted light. Those on the costal margin are somewhat stronger in structure and sparser in arrangement than those on the caudal margin and about half as long, and gradually decrease in length distad on the distal quarter of the costal margin; they are arranged in two lines alternately; those on one line are erect cephalad, while those on the other line are more or less bent distad. The fringe on the caudal margin (anal and outer margins) is very long, being fully 1.5 times as long as the widest portion of the wing itself, and most thickly arranged on the middle part of this margin; most of the hairs are arranged in a single line, being erect caudad, but the minority of the hairs on the outer margin is somewhat bent proximad, and at this part the fringe very gradually decreases in length distad.

The venation of this insect is very much reduced, being represented only by a few veins of slight thickening, most of them located on the proximal quarter of the wing area and ending on the costal margin. Vein C is broad and pale brown under transmitted light, the ambient vein (*av*) extends along the entire caudal margin of the wing and is as distinct as in the costal margin and about half as broad as the costa. Very slight thickenings of the membranes faintly indicate some of the other veins. The proximal broad part of the costal margin shows a double nature, being provided with a shallow longitudinal furrow; this double nature may be assumed to have been induced by the incomplete coalescence of the two veins C and Sc on this part. The most distinct is R_1 and the stem of R combined which terminates on C at about the proximal quarter of the length of the costal margin and is provided with about two placoid sensillae (*ps*) on the proximal end of R. The other vein, terminating on C a little beyond the end of R_1 , is R_s , which is almost atrophied on its proximal half, although faintly connected with the very slightly thickened small R_s , which is located at the middle of the distinct vein R. Cu is rather obvious, extending along the anal margin of the wing, nearly parallel to it, and almost atrophied before the wing margin. The other vein, probably M, is very faint and creaselike, located independently or freely but in the definite position on the middle part of the wing without connection with the other veins, being

completely atrophied both on its proximal and distal terminal parts.

THE LEGS

The legs (Plate 3, figs. 8 to 10) are uniformly pale yellow, very delicate in structure, slender, but comparatively short for the body length, very scantily haired with slender setæ, similar in structure and subequal in length, except that the forelegs are slightly longer and the hind legs shorter than the others. The three pairs of legs are very widely separated from each other and the distances between the fore and middle legs and the middle and hind legs are about equal to each other, being slightly more than the greatest width (on the scutellar region) of the thorax; the forelegs are articulated far dorsad of the usual ventral position, while two pairs are articulated in the normal ventral position.

The coxæ (*cx*) are unusually elongated, neither cylindrical nor conical, but somewhat flattened, and subdivided into the small proximal (*p*) and large distal (*d*) portions; the fore pair is somewhat stouter than the others. Each coxa is provided with several slender and a few curly hairs on the distal end and one to three slender setæ on the middle part. The chitinized proximal subdivision is very narrow, quite cylindrical, distinctly bounded by a narrow, ringlike, membranous, basicostal suture (*mc*) from the main division of the coxa, provided with two groups (one each on the cephalic and caudal side) of microscopic erect setæ; the proximal subdivision of the fore coxa is far shorter than that of the others. The distal margins of the coxæ are more or less incised triangularly on the dorsal sides; this incision of the fore pair is larger and deeper, and that of the hind pair is smaller and shallower than that of the middle pair.

The trochanters (*t*) are elongated, articulated to the coxæ with the distinct trochacoriæ (*to*), quite cylindrical, and provided with two to four slender setæ, and two isolated and one double placoid sensillæ (*sn*) on the distal part. Both ends of the trochanter are more or less chitinized; the proximal chitinization is larger than the distal, being provided with small trochantes (*ta*) against the trochacoilæ (*tc*) and the distal margin is very narrowly chitinized along the femasuture (*fs*). The anterior two trochanters are about half as long as the corresponding coxæ, while the hind trochanter is slightly shorter

than the hind coxa. The fore trochanter is shortest and stoutest, while the hind trochanter is longest and slenderest, being 1.3 times as long as the former.

The femora (*f*) are largest among the leg segments, more or less flattened and swollen on the distal part, subdivided into three parts; namely, the small proximal part (*p*), the membranous intermediate part (*mf*), and the large distal (*d*) part, being immovably articulated to the trochanters. The proximal part is very small and quite bare except for a common fine pubescence, and at this point the femur is distinctly narrowed, especially on the fore and hind legs. The intermediate membranous part is broad, ring-shaped, fully twice as large as the proximal part, quite smooth, hyaline, and provided with several placoid sensillæ (*sn*) on its ventral side. This part of the femur is slightly flexible. The distal part is large and fully twice as long as the two proximal parts taken together, with five slender marginal setæ, besides long setæ (four each on the anterior two femora and one on the hind); its distal margin is distinctly thickened, forming a pair of tibiacoilæ (*tbc*) (one on each lateral side) and sharply incised V-shaped on the ventral side. The fore femur is shortest and somewhat stouter than the others, and the hind femur is longest and slenderest, but about twice as broad as the trochanter. The fore femur is about 1.5 times as long as, and each posterior femur about twice or a little more than twice as long as, the corresponding trochanter; or the anterior two femora are a little shorter than, and the hind femur is subequal to, the preceding two segments (coxa and trochanter) taken together.

TABLE 1.—*Nymphomyia alba* Tokunaga; relative lengths of the leg segments.

[69 units = 0.2 mm.]

Leg.	Coxa.	Trochanter.	Femur.	Tibia.	Tarsus.					Total.	Claw.
					1st.	2d.	3d.	4th.	5th.		
Fore.....	39.5	21.3	50.1	56.2	31.0	19.0	15.0	13.5	34.0	272	14.0
Middle.....	45.0	25.4	55.3	53.8	26.0	20.2	15.8	11.5	28.1	266	12.7
Hind.....	32.8	27.9	56.0	51.5	19.7	15.0	12.0	12.0	18.6	227	11.0

The tibiæ (*tb*) are elongated, subequal in length to the corresponding femora, cylindrical and slender, except those of the middle legs which are somewhat swollen on the distal parts, and each tibia is subdivided into three parts (proximal, membra-

nous, and distal) like the femora. No tibia shows any trace of an apical spur or any spurlike projection. The articulation between the femur and tibia is strong, being provided with a thickly chitinized coila (*tbc*) and artis (*tba*) on each side, but rather simpler than the hypothetical articulation of the insect leg in losing such structures as the tibiaflexis, fematroelia, and patella. The proximal parts (*p*) of all pairs are small, without setæ, and subequal in diameter; those of the anterior two pairs are somewhat curved ventrad and each is about one-fifth as long as the tibia itself, while those of the posterior pair are more or less elongated, nearly straight, and about one-third as long as the hind tibiæ. The membranous parts (*mt*) are subequal in length, quite smooth, hyaline, and considerably enlarged on the flexor ventral surface; those on the anterior two legs are subequal in length to the proximal parts, respectively, and slightly greater in diameter; while on the hind legs these parts are subequal in diameter to the proximal parts and only half as long. The tibiæ are very slightly flexible and usually bent ventrad at these membranous parts, as in the femora. The distal parts (*d*) of the three pairs are considerably different in shape and length, but similar in structure to each other; they are each provided with one to three placoid sensillæ (*sn*) on the proximodorsal surface, three or four slender setæ scattered on the proximal half, and four or five slender setæ on the distal end. Concerning the relative length and size, this part of the foreleg is slenderest and longest among the three tibiæ, being very slightly greater in diameter than in the proximal part and about 2.5 times as long as the proximal two parts taken together. The distal part of the middle tibia is large and stout, being more than twice as broad as the proximal part and nearly twice as large as the distal part of other tibiæ, but far shorter than that of the fore tibia and subequal in size to the distal part of the hind femur. The distal part of the hind tibia is quite cylindrical, as in the fore tibia, and subequal in diameter to the latter, but far shorter and shortest among those of the three tibiæ, being only about half as long as the fore tibia itself.

The tarsi (*ts*) are all five-segmented, slender, and very scantily haired with a few minute setæ only on the dorsodistal end of each tarsal segment. Each of the third and fourth segments on all the legs is provided with an unpaired microscopic spine (*tp*) on the ventrodistal end. The articulations of the tarsal segments are more or less oblique, and there are a rather extensive membrane on the flexor surface and a tarsaflexis and

tarsatroclia on the extensor dorsal side between most of the segments. Each tarsal segment is somewhat enlarged on the distal part, the ventral surface of which is thinner in structure than the dorsal. The basal and ultimate tarsal segments on the same legs are nearly equal in length, and the proximal four segments are gradually shortened distad. The fifth tarsal segment, especially on its distal part, on all the legs is somewhat more pubescent with long microtrichia than the other parts and provided with the ordinary terminal structures but shows no trace of the pulvilli. The ratio in the length of the three tarsi is about 103 : 93 : 66, and thus the long forelegs possess long tarsi and the short hind legs have short tarsi, but the proportion in the length of each tarsus and the leg to which it belongs is quite different in the different pairs. On the foreleg the first tarsal segment is about half as long as the tibia and scarcely as long as the two following segments together. The first tarsal segment of the middle leg is also about half as long as the tibia but shorter than the following two segments taken together; the ultimate segment is subequal in length to the first tarsal segment and fully as long as the two preceding segments together. The tarsal segments of the hind leg are slightly stouter than those of the other legs; their articulations are distinctly oblique and each segment is far shorter than the corresponding segments of the other legs. Each of the first and ultimate segments of this leg is slightly longer than one-third of the tibia, or only slightly longer than half of the corresponding segments of the foreleg. Among the remaining three tarsal segments the third and the fourth are nearly equal in length, the total length of the above two segments being somewhat greater than the ultimate segment, and each segment is slightly shorter than the second tarsal segment.

The claws (*c*) are symmetrical in structure, slender and sharply pointed, quite glabrous, unserrated, not quite smooth, but with very fine oblique striation on the lateral side. The empodium (*e*) is elongated and slender, slightly shorter than the claws, and provided with many simple hairs. The calcanea (*cn*) is also slender, finely squamous, and without the onychium. The last two structures are directly fused with each other, losing such structures as the planta and auxilia. The tubercula (*tu*) is not distinctly projected distad between the claws, but thickened and emarginated ventrad, forming the "Glenkhöcker" (*gh*) against which the claws are articulated.

THE ARTICULATIONS OF THE LEGS, THE WINGS, AND THE HALTERES

The articulations of the legs are all very simple, and all the coxafossæ are very small. The forelegs are articulated laterally and widely separated from each other; each foreleg is provided with the coxartitis, which articulates against the coxacoila, but is without the distinct sternartitis. The middle legs are articulated ventrally, each with the sternacoila, and the distance between the middle legs is least among the three pairs. The hind legs are also articulated ventrally with the sternartitis against the sternacoila, but without the coxartitis and the coxacoila as in the middle legs. The distances between the three pairs are subequal and very long, due to the elongation of the thorax (Plate 2, figs. 5 and 7).

The articulation of the wing is very complex (Plate 2, fig. 5; Plate 4, fig. 13). There are four aliferæ on the pleurotaxis for the articulation of the wing; namely, the prealifera, meda-lifera, subalifera (pleuralifera), and postalifera. The micra-lifera is completely wanting. The prealifera (*pal*) is small, thickly chitinized, and located on the dorsal part of the broad lateral membrane. The medalifera (*ml*) is oval, slightly chitinized, and located between the prealifera and the notepisternum, and its cephalic part is attached to the prealifera. The subalifera (*pr*) is very thickly chitinized, somewhat C-shaped, and forms a strong main projection for the wing base, being closely associated with the dorsal projection of the notepisternum (*np*) and the notepimeron (*n₂*). The postalifera (*pol*) is oval, thickly chitinized, and located closely near the cephalodorsal margin of the parascutella (*ps₂*), and the spiralis (*sl*) is extended along the cephalodorsal margin of this sclerite.

Dorsad of the prealifera or near the costalis there is a small spinous tubercle which is the mesotegula (*te₂*). Besides these sclerites, along the lateral margin of the scutopræscutum (*sps₂*), there is a narrow, rod-shaped sclerite which is the ponta (*po*). The ponta forms a small, irregularly shaped structure at its caudal end which is complexly articulated to the prealifera, the subalifera, and the costalis.

The pteraliæ (Plate 4, fig. 13) are reduced in number, being represented only by the following distinct sclerites: Terminalia (duritæ), costalis, radialis, and analis (venellæ). Such duritæ as the sigmoidea, submedia, and navicula, and such funditæ as the costalla, mediella, and anella are almost completely atrophied.

The terminalia (*t*) is located between the subalifera (*pr*) and the postalifera (*pol*) and closely associated with the analis (*as*). The costalis (*cs*) is largest among the three venellæ, and the radialis (*ra*) is very small, somewhat lunate in shape, and anastomosed into the costa on its distal part. These two venellæ are articulated directly to the pleuralifera and the caudal end of the pontæ.

The notal processes for the articulation of the wings are greatly reduced. The medalaria is blunt and minute, far separated cephalad from the wing base, and has no direct mechanical relation with the wing movement. The scutalaria is also minute and situated close to the costalis. The caudalaria is obscure. The other alariæ are all completely atrophied.

The articulation of the base of the haltere (Plate 3, fig. 11) is very simple. The spherical proximal end, the scabellum (*sc*) of the petiole (*ptl*), is directly articulated to a swelling of the rotaxis (*bsr*). This basal swelling is homologous with the region where the various basal sclerites, such as the funditæ, venellæ, and perhaps the duritæ, may be found in the generalized wing base. At the cephalic region of the rotaxis (*r*) is a blunt membranous projection which is covered with distinguishable pubescence. This projection is the remnant of the metategula (*te₃*). The pteralæ, the alariæ, and the spiralis are obscure.

THE ABDOMEN

There are almost no sexual differences in the structure of the abdomen excepting the ultimate and penultimate segments. The abdomen of both sexes is pale yellow, feebly chitinized, slender, extremely elongated, and at rest slightly curved ventrad; superficially with nine distinguishable segments, including the hypopygium, quite cylindrical, the diameter nearly uniform throughout the whole length, covered with a fine microscopic pubescence, scantily haired with slender setæ and with a few scattered transparent patterns, brown tubercles, and various sensillæ on each segment. There is no trace of spiracles (text fig. 2).

The segments of this insect, except the first and two terminal segments, as a rule, are not subdivided into intrasegmental annulets, but provided with cuticular structures, as follows: The transversal thickening, which serves as an "antecosta" (*ac*) of the intersegmental muscles and becomes hidden in the intersegmental fold on contraction of the muscles, is located across the tergum closely along the cephalic margin, narrowed and highly chitinized on its mesal part but somewhat broad and thin

on its lateral parts. On the sternum there is no corresponding thickening. The distinct tubercles (*tb*) are arranged transversally on the caudal region of the tergum; the number of the tubercles is very irregular, varying from one to five pairs, and they are less in number on the cephalic abdominal segments than on the caudal; and, moreover, the male is provided with more of them than the female. Very close to the above tuber-

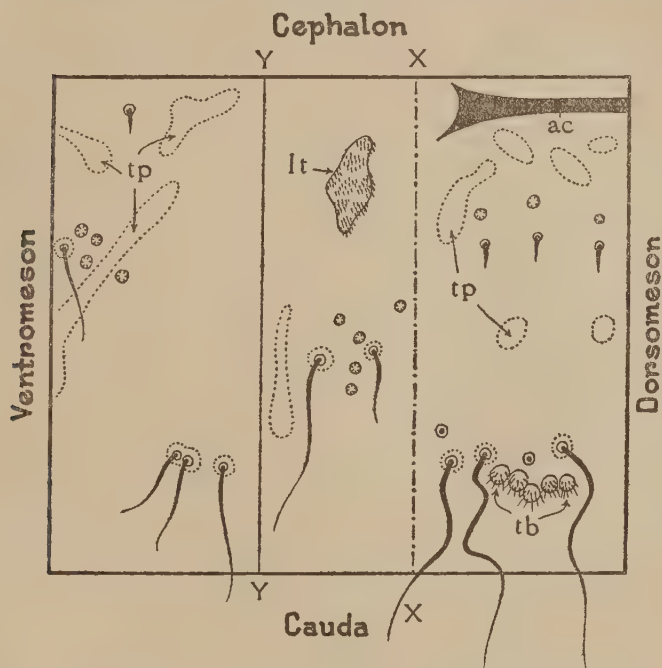


FIG. 2. Diagrammatic arrangement of the cuticular structures of the abdominal segment. *ac*, Antecosta; *lt*, lateral tubercle; *tb*, tubercle; *tp*, transparent pattern; X-X tergoparatergal line; Y-Y, tergopleural line.

cles are three pairs of long, slender, brown setæ and two pairs of minute sensillæ. The transparent patterns (*tp*) are scattered on the tergum; two pairs of them, which are round, are on the middle region, and four pairs located on the cephalic region or caudad of the cephalic thickening are somewhat oval, the lateromarginal pair being more elongated. Between the two groups of the transparent patterns are about six pairs of sensillæ; the cephalic three pairs are placoid, and the caudal three are trichoid.

On the lateral side, where the paratergal sclerites are located in certain insects, is a large, somewhat elongated tubercle (*lt*) on the cephalic region where the spiracle would be expected. This tubercle may be derived from the modified peritreme or other paratergal elements. Two slender setæ, one long and the other short, are located on the middle region of the lateral side where there are several minute placoid sensillæ. A large, elongated, transparent pattern is found ventrad of these setæ.

The pleural region, ventrad of the dorsopleural groove (*Y-Y*), is uniformly membranous with the sternum completely losing the pleural sclerites.

The sternum is not provided with tubercles and tubercules. There are about three pairs of slender setæ in the caudal region corresponding to those on the tergum. The cephalic region of the sternum is provided with two pairs of small setæ, of which the anterior pair is very small, hyaline, and may be trichoid sensillæ; the others are located near each other on the meson of the sternum. The transparent patterns of the sternum are large; a very large V-shaped pattern is located on the meson, a united or paired pattern on the mesocephalic margin, and a paired one on the laterocephalic margin.

The first abdominal segment is somewhat more elongated than the others, subdivided into two annulets on the dorsal side, bearing several pairs of strong setæ on the dorsocephalic margin, usually two pairs of slender setæ and about one pair of tubercles on the dorsocaudal region, two small setæ on each lateral side, and a large V-shaped transparent pattern on the ventral. The various other structures of the cuticle as shown on the other segments are very obscure or wanting.

THE TERMINAL ABDOMINAL SEGMENTS OF THE FEMALE

The terminal two segments (Plate 4, figs. 14 to 16) are very different in structure from the preceding segments, and the sexual differences are shown most clearly on these segments.

On the eighth, penultimate, segment of the female the tergum (*ot*) is broad, uniformly chitinized, thickly pubescent, and provided only with three pairs of slender setæ on the caudal region, one pair of minute trichoid sensillæ on the cephalic region, and two pairs of transparent round or oval patterns on the cephalo-lateral corners; the cephalomarginal thickening is very feebly developed, and the placoid sensillæ are quite obscure. The sternum (*os*) is almost membranous and covered with rather long pubescence; the cephalomesal region of the sternum is

swollen ventrad, while the caudomesal region is suddenly depressed dorsad. The cephalic margin (*at*) of the sternum is chitinized broadly and usually hidden in the intersegmental fold. Along this margin is a thin antecostal lamella. Along the mid-ventral line the swollen region is folded or doubled up deeply entad, forming a large but thin, chitinized, lamellalike endoskeleton (*ec*). These two endoskeletons serve as attachments of the various genital muscles. On the caudal half of the sternum or on the lateral margin of the depressed region there is one pair of distinct long setæ accompanied by three or four pairs of minute trichoid sensillæ very near each other. The caudal margin of the eighth sternum is folded dorsocephalad, forming a large membranous genital chamber (*gc*) between this segment and the ninth. In the innermost part of the genital chamber is the common aperture of the sexual glands, guarded by a slightly chitinized lunulate endapophysis (entogonapophysis or paramere). The lateral sides or the paratergal region (*pt*) of the eighth segment is quite characteristic in structure. The whole structure is more or less thickened and hangs down from the lateral margin of the tergum proper along the lateral side of the segment, forming a longitudinal tergo-pleural fold. The caudal part of this fold (*pj*) is extremely elongated ventromesad along the caudal margin of the sternum to form a cover of the genital chamber, and is provided with a conspicuous long seta on its basis. Besides this flattened caudal projection there are two distinct tubercles (*t*) on the tergo-pleural fold; one situated on the cephalic margin of this fold is thickened and large, while the other is somewhat small, provided with a minute seta, and located on the ventral margin of the fold or just caudad of the former tubercle.

The terminal region, including the ninth segment, caudad of the eighth segment, is small, about half as long as the preceding segment, and quarter-spherical in shape. The dorsal half of the spherical surface, the ninth segmacoria (*sc*), is very broad, membranous, and without setæ. The ventral half is more or less thickened, without tubercles and setæ, but with a pair of large cylindrical projections on the ventrocephalolateral corners. This projection, the cercus (*ce*), is not articulated but firmly fused to the body wall, bears many setæ, and with the nonfunctional remnant of the special muscles. At the basis of the cerci, on the membranous sternum and along the entrance to the genital chamber, is a pair of small, blade-shaped, and setigerous sclerites (*cc*), which are the cercariæ. The ventral side is mainly

membranous, except for the lateral margins (*ep*), which are a part of the tergum. On this part are four very long setæ, one of which is projected caudad, while the other three are directed ventrad. The ventral membranous area is rugous and subdivided into two regions, the cephalic and the caudal; the cephalic region (*pp* and *sa*) is somewhat swollen ventrad, while the caudal (*su*) is flattened. The anus (*a*) is located between these two regions.

THE TERMINAL ABDOMINAL SEGMENTS OF THE MALE

The penultimate and ultimate abdominal segments of the male (Plate 5, figs. 17 to 19) are highly modified and differ greatly in structure from those of the female. The eighth, or penultimate, segment is somewhat smaller than the preceding seventh, and not provided with the tubercles on the dorsocaudal region but with paired transparent patterns on the ventral surface. The cephalic margin (*at*) of the eighth tergum (*ot*) is narrowly and thickly chitinized and provided with a pair of small transparent patterns on the lateral parts of this chitinization. Besides the above small patterns there is a pair of rather large transparent patterns on the cephalic region of the tergum or caudad of the cephalic chitinization. On the middle part of the tergum are two small trichoid sensillæ, and on the caudal region three pairs of long slender setæ are transversally arranged. The caudal margin of the eighth segment is very thinly membranous and without microtrichia. The sternum (*os*) is somewhat thinner than the tergum and more scantily covered with rather long pubescence. On the cephalic region of the sternum are large, transparent, paired patterns and small trichoid sensillæ, and on the caudal region is one pair of long setæ. The lateral paratergal region (*pt*) of the eighth segment is provided with two, large, peculiar processes, which are subequal in length and parallelly extend caudad as far as the caudal margin of the eighth segment. The dorsal (*pj*₁) of these two projections is entirely covered with fine microtrichia and provided with a long seta on its ventroproximal part and with two small thickened tubercles (*t*), which are quite bare and situated close to each other on the ventroproximal base. The ventral projection (*pj*₂) is slenderer than the dorsal, quite bare, uniformly and thickly chitinized, and provided with a hooklike point at its distal tip. On the ventroproximal base of this projection is a large, smooth, earlike thickening (*t*), which is somewhat thin, convex laterad, and concave mesad. The above two

(dorsal and ventral) large projections are not independently movable, but work in union, being firmly fused to the common thickening by the common tergo-sternal muscles. At rest these two projections are closely situated along the body wall, but when the common thickening is pulled ventrad by the contraction of the tergo-sternal muscles, they can be extended horizontally or nearly so. The lateral surface of the eighth segment, besides the above distinct processes, is provided with two long setæ on the blunt colliculus and a small trichoid sensilla on the mid-lateral region. On the ventral side, between the eighth and ninth segments, is a very large membranous ædeagus (*aa*). The ædeagus is quite smooth, without pubescence, directly exposed externally, and supported by a chitinized framework (*pa*), the ectapophysis (gonapophysis or paramere), which subdivides the membranous region into two parts. The proximal region (*pb*) is very broad and as wide as the eighth segment itself, while the distal region (*p*) is very small and blunt.

The ultimate segment consists of the ninth and other posterior segments, paired large cerci, and coxites. This fused segment is very small and about a quarter as large as the preceding eighth segment; its dorsum is rather thinly membranous and covered with delicate pubescence; its venter is very thin and very scantily pubescent, and the macrotrichia is quite wanting on both surfaces. The cerci (*ce*) and coxites (*cx*) are firmly fused to this segment, and the demarcation between them is almost wanting. The cerci alone are distinctly demarcated only on the ventral aspect by the presence of the cercariæ (*cc*). The cercus is located dorsad of the coxite, extended ventrocaudad, setigerous on its dorsal side, and very scantily haired on its ventral side (*pp*), hairs being represented only by two long setæ, one on the proximomesal part and the other on the middle part. The basis of the cercus is very broad with a very long seta on its dorsomesal margin, while the distal part is sharply pointed and with many short setæ. The cercaria (*cc*) is very slender but distinct, claw-shaped, somewhat thickened, and quite bare. The coxite³ (*cx*) is very conspicuous, broad at its base, occupying the greater portion of the lateral aspect of the ninth segment, but slender on its distal half, extending caudad as far as the cercus, and gradually curved ventromesad. The entire surface of the coxite is covered with common pubescence,

³ The coxite is homologous with the subcoxa of the leg-bearing segment or with the limb base of the stylus and is commonly known as the "side piece."

but without any kind of macrotrichia. Its ventral ridge is provided with two rows of thick recurved pubescence along its entire length. The style⁴ (*s*) is very small and slender, somewhat curved laterodorsad and directed cephalodorsad. It is covered with common pubescence and without macrotrichia, not chitinized, and without chitinized hooks or claws. At the articulation of the style is a blunt lobe (*h*), which is also without setæ and covered with common microtrichia. This swelling is homologous with the so-called "harpe" of various nematocerous Diptera. The periproct (*sa* and *su*) is closely fused to the para-proct on the ventral side and situated at the caudal end of the abdomen between the cerci.

DISCUSSION

THE HEAD

Although the head of this fly is quite peculiar in the structure of all of its parts, its most extraordinary features are the prolongation of the head capsule, the complete reduction of the mouth parts, and the lateral position of the large ocelli.

In the Diptera the elongation of the head is of two types, representing two independent lines of evolution. The first type is derived from the modification of the mouth parts; the theca, which is homologous with the labial stipula of the generalized insect, is the main structure participating in the realization of this type. This sclerite often seems to take part in the formation of the head capsule, being located on the opposite side of the frontoclypeus and associated with the stipes. In various Diptera, such as the Culicidæ (*Psorophora*), Asilidæ, Cyrtidæ (*Eulonchus*), Conopidæ, Muscidæ (*Glossina* and *Stomoxys*), Tachinidæ (*Archytas*), etc., the elongation of the head is solely due to the elongation of the theca and accessory membrane. In various insects with extremely long probosces, such as the Culicidæ (Culicinæ), Tipulidæ (*Geranomyia* and *Elephantomyia*), Empidæ (*Empis*), Bombyliidæ (*Bombylius* and *Exoprosopa*), etc., the exceptional length is accounted for by the presence of the elongated paraglossæ, which, together with the elongated thecæ, augment the length of the proboscis. The second type of the elongation of the head is derived from the modification of the sclerites of the head capsule themselves, and this type is very rare among the dipterous insects, although

⁴ The style is homologous with the stylus of the Thysanura and is commonly known as the "clasper."

it is quite prevalent among certain other orders, such as the Coleoptera (Rhynchophora), Hemiptera, Anoplura, Mecoptera, etc. Among Diptera this type is only shown in such nematocerous insects as the Blepharoceridæ (*Bibiocephala*), Culicidæ (*Psorophora*), Dixidæ (*Dixa*), etc., and rarely, if at all, among the higher Diptera, such as Brachycera and Athericera. In these cases the prolongation of the head is mainly due to the elongation and modification of the frontoclypeus.

The head of the present insect, *Nymphomyia*, evidently belongs to the latter type, although it shows many important differences from the other insects included in the same type. Generally the elongation of the head in the second type is due to the cephaloventral prolongation of the frontoclypeus, which is more or less distinctly demarcated from the other sclerites, and the mouth parts become located eventually at the cephalic end of this prolongation. Moreover, the large caudal region, which consists of the vertex and compound eyes, usually retains a spherical shape or is slightly flattened and round. In the present insect the elongation of the head capsule is, contrary to the above, due to the modification of the whole head capsule. The cephalic snoutlike projection (Plate 1, figs. 1 to 3, *sn*), which is not provided with the mouth opening at its extremity, is not demarcated from the common head capsule; but, judging from the attachment of the muscles (dilators) of the basipharynx and the position of the antennæ, it may be homologous with the frontoclypeus or some parts of the frontoclypeus. The head of the female *Bibio* (Bibionidæ) is more or less modified on its cranial region, being slightly elongated and flattened, but the region cephalad of the antennæ, the frontoclypeus, is very small. In this respect the head of *Nymphomyia* is quite different in its constitution from that of *Bibio*. So far as the elongation of the head capsule is concerned, more intimate affinities with the present insect may be found among the most primitive groups of Nematocera, such as the Tipulidæ. Among the Tipulidæ the head of *Tipula* is distinctly elongated cephalad, forming a cylindrical prolongation, which, in turn, bears a distinct snoutlike projection on its dorsocephalic end. This snoutlike projection of *Tipula* is quite independent in structure of the mouth parts and is derived from the frontoclypeus. The mouth parts are located on the cephalic part of the prolongation, just beneath the snoutlike projection. The peculiar cephalic elongation of the head of *Nymphomyia* is easily derivable from that

of *Tipula* if one assumes enlargement of the part of the snout-like projection of the latter. A peculiar snoutlike structure of *Nemotelus* (Stratiomyiidae) also may be homologous with that of *Nymphomyia*, but the relative position of its mouth parts is quite different since it is hypognathous in type.

The position of the occipital foramen has the most intimate correlation with the shape of the head capsule. The head, which is round or spherical as shown in the higher Diptera,⁵ is almost always the hypognathous type (s. lat., including the orthognathous type); that is, vertical with the mouth parts directed ventrad, and the occipital foramen is located on the caudal aspect. The nematocerous groups are also hypognathous (orthognathous, s. str.), as a rule, but show gradual modification from the hypognathous to the prognathous in varying degree, according to the tendency of prolongation in the head itself. In insects provided with more or less elongated heads, such as *Rhyphus* (Anisopidae), *Mycetophila* (Mycetophilidae), and *Bibiocephala* (Blepharoceridae), the position of the occipital foramen is more or less excentric, having migrated dorsad, and more advanced modification is shown in such flies as the female in *Psorophora* (Culicidae), the female in *Bibio* (Bibionidae), etc., which have more-elongated heads. In the extreme case the head exhibits a prognathous type, rather than the hypognathous type, or nearly so, as in *Dixa* (Dixidae), *Limnobia* and *Tipula* (Tipulidae), etc. In this respect such a protonematocerous group as the Tipulidae shows a certain similarity to *Nymphomyia*, but the superficial similarity of these two types of the head is realized independently in various families and genera that have no direct phylogenetic relations between them. It is noteworthy, however, that this tendency is seen only among the Nematocera and not among the Brachycera and Athericera. The above discussion of the head of the present insect indicates that *Nymphomyia* should probably be included in the nematocerous group, although more information is needed to locate its exact phylogenetic position.

The relative size of the occipital foramen is more or less constant throughout the dipterous orders, as shown by Peterson, and relatively small on account of the small cervix. Even in

⁵ In certain parasitic groups of Diptera, such as the Hippoboscidae and the Streblidae, the head is highly modified secondarily from the hypognathous type, and the extreme case of this modification is shown best in the prognathous head of *Ascodipteron*.

the largest, as in the Psychodinæ, the area of the foramen is far less than a quarter of the caudal surface of the head capsule, while in *Nymphomyia* the foramen (Plate 1, fig. 3, *of*) is extraordinarily large, being nearly as large as the caudal aspect of the head itself. Moreover, the foramen of the Diptera is always provided with a pair of odontoideæ for the articulation of the cervapisterna, while in the present insect these processes are completely wanting, and the margin (*o*) of the foramen is quite smooth. Judging from the structures of the occiput in addition to other parts of the head capsule, the head of this insect shows a closer resemblance to the head capsule of certain eucephalous nematoceros larvæ, such as those of the Chironomidæ, Dixidæ, Psychodidæ, etc., than to the imaginal head capsules, as is evident in the following points: Prognathous in type, large occipital foramen, atrophy of the odontoideæ and the tentoriæ, and complete fusion of the head sclerites. In point of movability the head of *Nymphomyia* is thought to be limited within a narrower range than the heads of the other Diptera, which are provided with a small occipital foramen and well-developed odontoideæ, since the large occipital foramen of the Nymphomyiidæ is connected with the thorax by a very narrow cervacoria. The complete atrophy of the cervical sclerites supports this assumption.

The mouth parts of the dipterous insects usually undergo reduction in the number of the constituent appendages, as exhibited in the hypothetical case, and become more or less membranous as a whole. This reduction and modification occurs in various families and genera of Diptera in different degrees. Atrophy takes place in the mandible, lacinia, and glossa as the first step of reduction, and then in the galea as the second step. Both or either of the paraglossæ and maxillary palpi remain to the last.

Generally the paraglossæ are extremely well developed among the Diptera and constitute the important mouth parts. Even in certain Chironomidæ, such as the genera *Pontomyia* and *Clunio* which have highly reduced mouth parts, the female is provided with a trace of the paraglossæ and the male with tiny but more prominent paraglossæ, as I reported in 1932. So far as I know, except in the case of the parasitic Diptera, the complete atrophy of the paraglossæ is only known in the Deuterophlebiidæ, in which neither sex has a trace of the maxillary palpi or the paraglossæ, and in the present family, Nymphomyiidæ. The maxillary palpi are not reduced and usually have three to five

segments among the Nematocera, while in the Brachycera and the Athericera they are highly reduced or modified and show a nonsegmental condition; but the reduction of the palpus is not very rare even among the Nematocera, and the nonsegmented palpi are often found among certain gall midges and true midges. The complete reduction, as seen in the present insect, however, is very rare in free-living nematocerous insects, and examples are found only in the famous *Deuterophlebia* and the female in *Pontomyia*. As mentioned above, the mouth parts of *Nymphomyia* are closely related to those of *Deuterophlebia*, not only in the degree of reduction but also in the peculiar location of the mouth-opening, which is in the pocketlike chitinized mouth concavity. This cavity (Plate 1, figs. 1 and 2, *mc*) is located on the proximoventral side of the cephalic frontoclypeal projection (*sn*), which in the latter genus is far smaller and blunter than in the former. The labiumlike projection (*lp*) of the present insect is quite unique for the Diptera, and the exact homology of this projection is not yet known, although it might have been derived from such sclerites as the mentum or submentum or, more probably, from the theca or fused stipites, since the latter sclerites are far more stable in the Diptera than the former sclerites.

In spite of the complete reduction of the external mouth parts, the propharynx and the hypopharynx, it seems that the structures of the basipharynx and the œsophageal pump and those of the salivary system retained (text fig. 1) suggest the possibility of a functional action of these organs for taking liquid food. This question is very problematic in the natural life of *Nymphomyia*, because the epithelial layer of the midintestine is completely degenerated, being now represented only by a single delicate membrane, which has lost the characteristic epidermal structures; the thin epithelial cells of the salivary glands are highly reduced, now showing no trace of secretory features (although often the saliva is preserved within the glands of the imago, it may be a remnant of the secretion produced in earlier stadia); and experimentally the fly never takes food offered to it, such as water drops, honey water, sugar water, salt water, etc.

The presence or absence of the ocelli is vastly important for the phylogenetic consideration of the dipterous insects since the distribution of ocelli is strictly characteristic of different phylogenetic lines. All Athericera have three ocelli (except only the Conopidæ, in which the ocelli are wanting). Brachy-

cera also have three ocelli (except only the Tabaninæ, in which the ocelli are usually wanting), and in the pupiparous group both the ocelli and compound eyes are reduced in various degrees. Among the Nematocera the ocelli are present only in certain superfamilies or families, such as the Trichoceridæ, Blepharoceridæ, Mycetophilidæ, Anisopidæ, certain ceratopogonids,⁶ cecidomyiid Lestremiina, and Bibionoidea. The ocelli (Plate 1, figs. 1 to 3, *oc*) of the present insect are highly peculiar and obscure their true nature, suggesting at first the spiracles or the metatentorinæ. The peculiarity is shown, first, in the complete atrophy of the middorsal ocellus and, secondly, in the lateral position of the extremely large paired ocelli. That these lateral organs of the Nymphomyiidæ are true ocelli is shown by the presence of the lenslike, very slightly biconvex, glassy structure; of the subcuticular pigments, which are regularly arranged in certain limited cells; and in the absence of any trace of tracheal branches and other spiracular structures associated with them that might suggest homology with the spiracles, as well as in the absence of thickened invaginations that might suggest homology with the tentorinæ. Symphyla alone is known to possess spiracles on the head, and no other insect is known to simulate this peculiar location of the first pair of spiracles on the head. The metatentorinæ are often shown on the caudal aspect of the head capsule among insects, and sometimes they become very large, as in the Tipulidæ (*Tipula*, *Ctenacroscelis*, etc.). From these facts, taken in connection with the other features, these lateral organs may well be considered as ocelli or eyespots. This hypothesis is conclusively supported by the fact that these organs are in direct connection with the strong but short nerve fibers (ocellar nerve) arising from the protocerebral lobe.

There are many examples among the Hemiptera, such as the Henicocephalidæ, the Reduviidæ, etc., where the median ocellus is completely atrophied, and only two ocelli remain conspicuous, but among the Diptera such cases are very rare, occurring only in certain *Mycetophila* (Mycetophilidæ), *Canthyloscelis* (Scatopsidæ), *Oncodes* (Cyrtidæ), and *Culicoides* (Ceratopogonidæ). Although in the hemipterous insects the two ocelli have migrated more caudad or caudolaterad than in the other orders, the ocelli in the Diptera are almost always on the dor-

⁶ Jobling, B., Bull. Ent. Res. 18 (1928) 211-236, reported two vestigial ocelli in *Culicoides*.

somedian region between the compound eyes in the dichoptic type, and just caudad of the eyes in the holoptic type. In both cases the ocelli are never as far remote from each other as in the present insect. Besides the above differences of the ocelli between this peculiar insect and all the other dipterous insects, the ocelli in *Nymphomyia* are extraordinarily large, and their structure as a whole is not so compact and solid as in the so-called ocelli. In this respect, as well as in the other features mentioned above, these lateral organs of the present insect appear of somewhat different origin from the ocelli found in the generalized dipterous head, although they have some affinity to the ocelli or eyespots on the massive head of the larvæ of many eucephalous Nematocera, or those found on the adult head of certain Nematocera, such as the marine Chironomidæ. In these cases the eyespots are represented by organized masses of pigment-filled cells, which are almost nonspecialized hypodermal cells communicating with poorly developed nerve endings, as in the larvæ of *Ceratopogon*, shown by Hesse, where no corneal layer, eye lens, or vitreous layer is differentiated differing from the highly developed primitive ocelli. The hypodermal pigmental masses of the adult head, as shown in the Chironomidæ, are never located in the position of the primary ocelli of the Diptera, but are usually found on the lateral aspect, as in the larval eyespots mentioned by Saunders in *Paraclunio* and by Tokunaga in *Clunio* and *Telmatogeton*. In the female *Pontomyia* these pigmental spots have migrated far ventrocephalad, being situated on the cephalic aspect of the flattened head or ventrad of the compound eyes, and each occupies a fairly large area. The anomalous position of these pigmental masses, in addition to their structures, suggests a certain relationship between the lateral organs of *Nymphomyia* and the eyespots of the above-mentioned insects. Although Saunders suggests that the pigmental spots on the head of *Paraclunio* are some organs other than the ocelli, since they are not accompanied by the definite nerve, since the whole of them are subcutaneous, and since the hypodermis passing over them is unbroken, it is very difficult to compare such primitive organs as the eyespots with the ocelli found on the adult heads or on the heads of nymphs and naiads. Moreover, the nerve system communicating with the eyespots is not always so distinct as in the true ocelli, and it probably is represented by very fine neurofibrillæ, as in the peripheral nerve system, which are almost impossible to demonstrate by the usual histological technic. As previously noted,

the so-called "ocelli" of the *Nymphomyia* are thought to be different in origin from the primary or dorsal ocelli of insects, and may be more closely related to the eyespots or larval adaptive ocelli of the nematocerous larvæ or those of certain adult midges.

The antennæ of the present insect (Plate 1, fig. 4) are quite brachycerous in type in their general appearance and in the reduction of the flagellum segments. The antennæ of the Diptera, as a whole, show a wide range of development, but in the majority of the genera the main line of specialization is toward the reduction of the flagellum segmentation. On the other hand, the scape and the pedicel undergo only a slight change. Examples of the simple reduction in the number of the flagellum segments are found even among the nematocerous Diptera, such as the females of certain genera of the Chironomidæ and both sexes of the Deuterophlebiidæ, but in all these cases, although the length or size is more or less divergent, the differentiation among the flagellum segments is very slightly developed, and all the segments of the antennæ are subequal in shape and structure as shown in *Tanytarsus*, *Chironomus*, *Pentapedium*, *Deuterophlebia*, etc. The segmental differentiation of the flagellum of the Nymphomyiidæ shows rather a closer similarity to that of the Brachycera, especially the Empidæ, than to that of the Nematocera, but this similarity of the antennæ is not thought to represent a direct phylogenetic affinity between the present family and the Brachycera. On the other hand, the presence of the intersegmental sensillæ (Plate 1, fig. 4, *is*) on the flagellum in the present insect is quite peculiar among the adult antennæ of the Diptera, since the various sensillæ found are always located on the segments themselves and never on the intersegmental coriæ, although the intersegmental sensillæ are very common in the larval antennæ. As mentioned above, it is noteworthy that the Nymphomyiidæ, which show many primitive nematocerous characters, are provided with peculiar antennæ whose appearance is strongly suggestive of the antennæ of the higher Brachycera, although they are not absolutely identical with the latter.

The antennariæ of the Diptera are more or less closely united with the common head capsule, and their demarcations generally become obscure, both in the Orthorrhapha and the Cyclorrhapha. Their independent existence is plainly shown only in certain limited families or genera of the nematocerous groups that are

provided with large antacoriæ or accessory membranous areas; such as, the Tipulidæ, Chironomidæ, Trichoceridæ, Culicidæ, Mycetobiidæ, etc. Both the absence of the independent antennariæ and the great reduction of the membranous areas of the antecoriæ of the present fly are closely related to the modification of the antennæ themselves. In the majority of the cases where the antennariæ are superficially atrophied, the antacoilæ, which properly belong to the antennariæ, are more or less distinctly retained on the membranes of the antennal sockets, and especially often in the Nematocera along the margins of these membranes, ring-shaped sclerites, which are homologous with the antennariæ, are more or less distinctly demarcated from the head capsule, as I have indicated in the case of a certain crane fly. Thus, the antennariæ, although not developed as free independent sclerites, may be more widely present, in the state where they are fused with the adjacent sclerites of the head capsule, among the dipterous insects than Peterson and others suspect. In the present insect also the antennariæ are more probably fused with the common head capsule than completely atrophied.

The sexual variation of the compound eyes is most prevalent among the Nematocera and Brachycera, but in *Nymphomyia* the sexes are very similar in structure, size, and shape. The compound eyes of the Diptera, as a rule, are either separated from each other, the dichoptic type, or two sides of them are contiguous on the dorsal side, the holoptic type, but in *Nymphomyia* the two sides are only contiguous on the ventral side and widely separated on the dorsal side. The extent of the holoptic condition is said by Peterson to depend upon the size of the compound eyes and the location of the antefossæ. In spite of the facts that the antennæ are located close to each other and far remote cephalad from the compound eyes, and that the antefossæ are exceedingly small, the compound eyes in both sexes of this insect are expanded ventromesad and exhibit a unique modification of the holoptic type quite unknown in the Diptera.

The visorlike ridge (Plate 1, fig. 2, *vp*) near and over the bases of the antennæ is quite different in origin from the ptilinum,⁷ which is constantly found along the frontal suture of the higher dipterous group Schizophora, since there is no invagina-

⁷ In the mature adult stage the ptilinum, as a rule, is completely infolded entad, but very often in certain anthomyiid flies this structure remains external and thickened, forming a crownlike projection.

tion of any kind or endoskeleton associated with it. It is apparently a simple projection of the vertex, which is found in varying degree among the Nematocera; for example, the "frontal tubercle" of the Chironomidæ, the "frontal crest" of the Tipulidæ, etc.

The tentorium undergoes a considerable reduction in the different families, genera, or species and is associated with the reduction of the mouth parts. The complete degeneration of the tentorium occurs on the supratentorium alone, and the other tentoria (anterior and posterior arms) are more or less retained even in the head, which has no functional mouth parts, as seen in *Chironomus*, *Tanytarsus*, and certain other nematocerous flies. In a more reduced or more specialized case the tentorium is not developed as the endoskeleton; in this case it is represented by the external thickening of the gene, as shown by Peterson in the head of *Schizophora*. But in the case of *Nymphomyia* the tentorium has completely disappeared, as in the eucephalous head capsules of the dipterous larvæ greatly differing from the cases mentioned above.

THE THORAX

The peculiar feature of the thorax of this insect is mainly due to the extreme elongation of the cylindrical thorax. The thorax of the nematocerous insects, as a rule, is highly convex in both dorsal and ventral directions, so that the height of the thorax is rather greater than, or at least subequal to, the longitudinal length; and the thorax of the higher dipterous groups, Brachycera and Athericera, is flattened on the dorsum and somewhat angulated along the lateral margins, so that the width of the thorax more or less approaches its length. The thorax of the present insect is very much elongated, being about thrice as long as the greatest width; such extreme elongation of the thorax, so far as I know, is quite new among the dipterous insects, even among the lower groups, such as the Tipuloidea and Psychodoidea. This elongated and cylindrical feature, which is exhibited only in the immature stages in dipterous insects, may be taken as a more primitive character from the evolutionary point of view. If so, this species, which in this feature is unique among known Diptera, may represent a very primitive form. Although this unique structure of the thorax reminds one of that of certain immature forms rather than that of the imaginal forms, other morphological features, such as the possession of

the large mesothorax, which occupies the major part of the entire thorax, the extremely developed mesopostscutellum and the highly reduced metathoracic notum, taken in connection with other structures, show that it is unmistakably a dipterous adult in form. Moreover, thoracic characters, such as the fairly well-developed pronotum (*an* and *pn*), although it is small for the extreme development of the mesonotum, and the nonangulated mesopleural suture (*p₂*) show that this fly belongs to the Orthorrhapha, more particularly to the Nematocera (Plate 2, fig. 5). Finally, the large, isolated, sternal sclerites, taken in connection with their constitution and the small vestigial pleural sclerites, are thought to symbolize a rudimental or primitive condition of their own phylogenetic development among the dipterous insects.

The cervix of the Diptera, as a rule, is very small for the size of the head capsule, while that of *Nymphomyia* is large in comparison with the small head capsule, which is subequal in diameter to the thorax itself. This large diameter of the cervix is distinctly proportional to the large occipital foramen. The pronotum is usually divided transversely by a secondary suture into two parts; namely, the antepronotum and postpronotum, but these parts (at least the antepronotum) are not completely separated longitudinally at the middorsal part. In cases where they are superficially separated into paired lateral portions, the lateral pairs are actually continuous with each other by a very narrow ental chitinization along the cephalic margin of the mesopræscutum, as I have suggested in the case of *Pontomyia*. In the thorax of *Nymphomyia*, on the contrary, both the antepronotum and the postpronotum are completely and widely separated into paired lateral portions by a wide membranous area (Plate 2, fig. 6, *mc*) at the dorsomeson, and the chitinized pronotal bridge is completely lost. Moreover, the paired lateral portions (Plate 2, fig. 5, *pn*) migrate far caudad as if they belonged to the mesopleuron proper. This anomalous position of these sclerites, however, is foreshadowed by the caudal migration of the postpronotum along the lateral margins of the mesonotum, as in the Anisopodidæ, Mycetophilidæ, Blepharoceridæ, Chironomidæ, Culicidæ, etc.

Another peculiar feature of the prothorax is the position of the coxæ. Among the dipterous insects the procoxæ are always articulated ventrally, even in the chironomid midges, where the prolegs are more widely separated from each other than in

other insects. In the present insect they are widely separated and articulated laterally. As a consequence the pleural area (Plate 2, fig. 6, *pp*) is very much reduced between the large notum and the dorsally migrated coxafossa, and is represented only by the procoxacoila. This remaining chitinization is probably derived from the proepisternum alone, completely losing the epimeral chitinization, since among the dipterous insects the undivided condition of the pleuron is never found as well marked as in the other higher orders, and when the reduction occurs on the pleuron the proepisternum remains more stable than the proepimeron. In contrast with the very small pleura, the sternal region (Plate 2, fig. 7, *pst*) is very large, being represented by a large chitinized sclerite. Such a large sternum⁸ is never found among the dipterous flies, and, taken in connection with the undivided sternum, which is completely isolated by a membranous area from the adjacent sclerites, reminds one of the primary sternites (Snodgrass) of the Apterygota or the immature forms of the Trichoptera, Odonata, and other orders that have the nymphal or campodeiform early stages.

On the mesonotum of the present insect the scutal suture (suture between the præscutum and the scutum) is completely obsolete, but this is not rare among the Diptera, since it is present only in certain families, such as the Tipulidæ, Trichoceridæ, Tanyderidæ, and Blepharoceridæ, and completely atrophied or greatly reduced in the majority of the Nematocera. The scutopræscutum (præscutum-scutum) and the scutellum are very similar in structure to those of the hypothetical thorax, except for the extraordinary elongation of the former and the distinct flattening of the latter sclerite.

The extraordinary development of the postscutellum (Plate 2, figs. 5 to 7, *pl*₂) of *Nymphomyia*, which is larger than the preceding notal sclerites (*sps*₂ and *su*₂) taken together, represents the most peculiar structure of this thorax. Generally this sclerite is well developed in the lower Orthorrhapha, especially in the Nematocera, but far smaller than half of the scutopræscutum taken alone, even where it is most elongated, as in the Ptychopteridæ. Furthermore, this sclerite is more or less ex-

⁸ The broad sternal sclerites are found in the thorax of the Streblidæ and allied families, which are of the most aberrant groups of the Diptera, but in this case the broad sternal condition is evidently derived from the secondary modification of the depression of the dipterous thorax, due to the parasitic adaptation.

tended ventrad or caudoventrad along the precostal margin of the first abdominal segment, hence the thorax, as a whole, appears to be truncated at the caudal end of the scutellum, as distinctly shown in the Cyclorrhapha. This tendency of the postscutellum is already shown in the lower Diptera, being especially pronounced in such nematocerous groups as the Ptychopteridæ (*Ptychoptera* and *Bittacomorpha*), Mycetophilidæ (*Bolitophila*), and Trichoceridæ (*Diazosma*), while in the present insect, contrary to the above general character of the postscutellum, this sclerite (pl_2 and en_2) is extended far caudad, and almost straight, deeply intruding into the first abdominal segment⁹ and forming a phragma.¹⁰

The postscutellum (Plate 2, fig. 5) of this insect is also distinctly divided into paired lateral portions (parascutellæ or pleurotergites, ps_2) and the unpaired median portion (mesascutella or mediotergite, m_2) as in the generalized dipterous thorax. In various nematocerous groups the parascutella is more or less extended ventrad, ending near the base of the haltere or the metaspiracle. Among the Mycetophilidæ this sclerite is more extended ventrad and beyond the metaspiracle. Especially in such mycetophilid gnats as the species of *Mycetophila*, *Diomonus*, *Platyura*, *Asyndulum*, and certain other genera, this sclerite deeply intrudes ventrad or ventrocephalad into the mesoepimeron, and sometimes is almost contiguous with the base of the mesocoxa. As a result of the extreme progression of this tendency, the following unique sclerotization of the present insect is considered mainly to have been derived: The caudal half of the pleural side is almost entirely represented by the broad expansion of the parascutella; the ventral region of the postscutellum is unusually expanded ventrad, forming a broad thickened wall of the sternal side and directly contiguous with the parasternite; the mesonotepimeron is nearly pushed out of its normal position by the cephalic extension of the parascutella; and the mesosternepimeron is widely separated from the mesonotepimeron by the deep cephalic intrusion of the parascutella along the epimeral suture. Another peculiarity derived from this unique parascutella is the relative position of the posterior

⁹ A similar feature is shown in certain Hymenoptera, *Pepsis* sp., by Snodgrass (1909).

¹⁰ This phragma is probably derived not only from the mesopostphragma but also from the direct fusion of the narrow metaprephragma with the intruding mesopostscutellum, losing the intersegmental membrane.

two pairs of legs. In all the dipterous insects they are always located close to each other, while in *Nymphomyia* alone the articulations of the meso- and metacoxæ are very widely separated from each other by the broad extension of the ventral region of the parascutellæ.

Thus, in the Nymphomyiidae we can trace, though with some difficulty, the homologous relation or evolutionary line of the postscutellum, but so far as the development of the parascutellæ is concerned, the present insect is so different from all known recent Diptera that their affinity cannot be discussed.

As is generally the case in insects, the Diptera, as a whole, are provided with a well-developed mesopleuron (including the præcoxale), which is clearly divided by the pleural suture into the episternum and epimeron. The episternum is usually subdivided into the notepisternum and the sternepisternum by the episternal suture. The epimeron is also subdivided into the notepimeron and sternepimeron by the epimeral suture. In the present insect the pleuron is vestigial, and its major portion is represented by a uniform membrane, so that these sutures are almost invisible, the pleural suture (Plate 2, figs. 5 and 7, p_2) alone being faintly represented by an incomplete, slightly undulated, creaselike line. In this vestigial and membranous condition the thorax of the present insect differs greatly from that of the Diptera in general, but is rather similar in appearance to that of the Apterygota or the immature forms of other insects. The pleural suture is always distinctly present on the dipterous thorax and serves as an important index in the phylogenetic consideration of the Orthorrhapha as pointed out by Crampton. The nematocerous groups alone have more or less straight pleural sutures, while the brachycerous and athericeous insects have always sharply angulated sutures. The pleural suture of the present insect simulates the condition of the former type, and this fact, even by itself, entitles this insect to a place in the nematocerous group, as I have already suggested in connection with other structures.

The notepisternum becomes more or less membranous in various nematocerous insects and sometimes it is completely reduced into a uniform membrane, which is continuous with the rotaxis as seen in the thorax of *Deuterophlebia* and *Edwardsina*, but this tendency taken alone has no particular phylogenetic significance in the nematocerous group, since such a reduction of the notepisternum occurs sporadically in varying degree

within the same major group or in closely related groups. Contrary to the above feature of the notepisternum, the sternepisternum is always highly developed in the dipterous thorax, and the wide distance between the anterior two pairs of legs is chiefly due to the development of this sclerite. Moreover, among the nematocerous groups the sternal area between the fore and middle legs is often completely or almost entirely represented by the ventrally expanded region of the sternepisternum (formed by the fusion of the episternum proper and the præcoxale) in place of the mesosternum as seen in *Tanytarsus*, *Chironomus*, *Microtendipes*, and other midges. In the present insect not only the notepisternum but also the sternepisternum has become membranous, and only the ventral margin of the pleuron is chitinized. Furthermore, the sternepisternum (Plate 2, fig. 7, *et*₂) is not extended ventromesad, differing in this respect from that of the generalized dipterous thorax, but remains in the proper position as in certain other Panorpoidea (Trichoptera and Lepidoptera), being widely separated from that of the opposite side on the ventromeson by the well-developed mesosternum and its accessory membranous area.

With regard to the epimeron of the present insect (Plate 2, fig. 5), as already suggested, the notepimeron (*n*₂) and sternepimeron (*se*₂) are very small and completely separated from each other along the epimeral suture by the deep cephalic intrusion of the parascutella, which reaches the pleural suture. This complete separation of the epimeron (*em*₂) is also a peculiar character for a dipterous insect since the two subdivisions of the epimeron, however widely they may be separated by the intruding parascutella, are always directly contiguous with each other along the cephalic corner of the parascutella, as in the higher Nematocera (Mycetophilidæ and Bibionidæ) and the lower Brachycera (Leptidæ). The notepimeron of the present insect contracts cephalad and becomes a small sclerite, which appears superficially to be one of the basal wing sclerites. This condition is brought about by the cephalic intrusion of the large parascutella, which has become directly contiguous with the cephaloventral margin of the large pleurotaxis and shifted the postalifera caudad along this margin.

Thus, the great modification and peculiarity of the mesopleural sclerotization of this insect are chiefly due to the extremely anomalous development of the parascutellæ accompanied by the membranation of the pleuron itself.

According to Snodgrass the typical definitive sternum (text fig. 3) consists of the three primary sclerites, presternum (*Ps*), basisternum (*Bs*), and sternellum (*Sl*), and two kinds of the secondary sclerites, spinasternum (*Ss*) and paired laterosternites (*Ls*). These sclerites are often highly variable in form, position, and extent of the development among closely allied groups, and study of their homology is extremely difficult, especially in the highly modified thorax such as of the Diptera. On the mesothorax of the lower nematocerous Diptera, Tipulidæ, Crampton has pointed out the following sternal sclerites: The presternum, basisternum, prefurcasternum, postfurcasternum, and laterosternites. The terminology of these writers differs, but it seems that the presternum of Snodgrass includes both the presternum and the basisternum of Crampton, that the basisternum and the sternellum of the former are homologous with the prefurcasternum and the postfurcasternum of the latter, respectively, and that the spinasternum is quite original with Snodgrass.

In the case of the Nymphomyiidae the mesosternum consists of two distinct sclerites. The cephalic sclerite (Plate 2, fig. 7, *prs*₂), the so-called sternannum,¹¹ is conspicuously separated from the caudal one (Plate 2, fig. 7, *bs* and *sm*₂), the so-called sternellum, by the membranous transversal area (*ss*), which is provided with a pair of small setæ (these setæ are very difficult to detect on account of their delicate structure). The setigerous nature of this membranous area suggests that it is different in origin from the furcinæ or their derivatives and probably a secondary development, where flexibility is demanded. If so, these sclerites cannot represent the sternannum and sternellum of MacGillivray. The presternum (Snodgrass, text fig. 3, *Ps*), which is clearly shown in the thorax of the Embiidæ (*Cylindrachæta*), is more probably homologous with this cephalic sclerite (Plate 2, fig. 7, *prs*₂) of the present insect. In the Tipulidæ, the sclerite homologous with the presternum (Snodgrass) consists of the presternum and basisternum (Crampton), but in the present insect such secondary subdivision is found neither externally nor internally on the cephalic sclerite, and it is always represented by one large uniform chitinization. The caudal sclerite of the present insect is provided with a pair

¹¹ MacGillivray divides the sternum into two sclerites, such as the sternannum and sternellum, according to the position of the furcinæ.

of small sternacoilæ (*sc*₂) and a V-shaped invagination of the furcæ on its cephalic region. These structures of the caudal sclerite show that it is homologous with the furcasternum (Crampton). The furcasternum or its homologous sclerite, the primary sternum, is subdivided by a thickened transversal invagination (text fig. 3, *fs*) into the pre- and postfurcasternum (Crampton) or the basisternum and sternellum (Snodgrass). This subdivision can be followed in the small V-shaped membranous area and the caudal elongated thickened area of the present thorax. Concerning the origin of the longitudinal ental ridge (usually known as the midventral suture) of the caudal sclerite, two hypotheses may be advanced. This ridge may have been derived from the median spina of the spinasternum through its cephalic extension, or its origin may be traced back to the common invagination (the V-shaped transversal thickening or transternal suture) of the furcæ, which has become extended caudad accompanied by the ental invagination of the sternellum, as in the "Sternagrat" (Weber) of the basisternum of many pterygote insects. The former hypothesis considers the caudal sclerite as a fusion product of the primary sternum and the secondary spinasternum, but this secondary intersegmental sclerite occurs only in the thorax of certain nymphs and of certain lower Orthoptera and is completely wanting in Diptera in general. This longitudinal invagination of the Diptera extends throughout both the meso- and metafurcasternum and is always completely continuous with the common invagination of the furcæ, both externally or in the sutural structure, and internally or in the apodemal structure. Thus, in so far as this longitudinal ridge is concerned, the latter hypothesis, in which the primary sternum is secondarily modified by the development of an apodemal brace derived from the furcæ where rigidity is demanded, seems more natural, and therefore more reasonable than the former hypothesis.

The laterosternites (*s. str.*), which originate from the subcoxal elements, are found around the coxafossæ in the hypothetical thoracic segment, but in almost all insects, except the Apterygota and nymphal forms, and especially the Diptera, they are firmly fused with the primary sternum, even in the Protonematocera. In the present case the laterosternites are also regarded as completely fusing with the caudal elongated sclerite instead of being completely atrophied, since the trace of the subcoxal elements (special parts of the laterosternites) is

shown as a pair of slender lateral thickenings, the precoxal bridges or præcoxales, which are located cephalad of the coxa-fossæ and united with the primary sternum proper.

To summarize, this sclerite is considered as consisting of the two divisions of the definitive sternum, namely, the basisternum and sternellum, and the subcoxal elements, namely, the latero-sternites and precoxal bridges (text fig. 3).

Besides the sternal sclerites already discussed, there is, on the sternal membrane, closely along the ventral margins of the mesoparascutellæ, a pair of thickened areas that in the present paper are conveniently described as the parasternites (Plate 2, fig. 7, *pt*). The homology and origin of these sclerites is difficult to discern. However, in all probability they were derived either from the secondary chitinization of the sternal membrane or from certain postscutellar sclerites homologous with the katapleurotergites (Young).¹²

The external chitinization of the metanotum is completely wanting or greatly reduced secondarily in the Diptera, although rarely distinct and less modified as in *Psychoda* and the allied genera, and generally it is represented by a very narrow semi-chitinized band of integument connecting the bases of the hal-

¹² The parascutella (MacGillivray) or pleurotergite (Crampton) is subdivided by Young (1921) into two sclerites: the anapleurotergite and katapleurotergite. Although Young did not discuss the distribution of these sclerites among the Diptera, they are shown by his figures in the following groups of the Orthorrhapha: the Calypterae (excepting the Dexiidae-*Thelaria*) and the Acalypterae (excepting the Micropezidæ-*Calobata*, Piophilidæ-*Piophila*, Ephyrinidæ-*Parydra*, and Oscinidæ-*Chlorops*) and never shown in the lower Diptera such as the Athericera, Brachycera, and Nematocera.

Each lateral portion of the mesascutella is subdivided by MacGillivray (1923) into two sclerites: the parascutella and durascutella. He said that the parascutella sometimes extends onto the pleuron and forms a distinct area, as in the Diptera, between the mesepimeron and the metepimeron, and that the durascutella is the infolded longitudinal thickening on each side separating the mesascutella from a parascutella. From his statement the parascutella may be homologous with the pleurotergite (Crampton) or the ana- and katapleurotergites (Young) taken together. Hence the ana- and katapleurotergites cannot be homologous with the dura- and parascutellæ, respectively. The durascutella of the dipterous thorax has been long neglected by many writers, but I reported the presence of the homologous sclerite on the postscutellum of a certain marine crane fly, *Limonia* sp., in 1930, and I found thereafter wide distribution of this sclerite among various crane flies where it is developed in different degrees.

teres or by an intersegmental membrane between the infolded mesopostscutellum and the precostal thickening of the first abdominal segment. The metanotum of the present insect distinctly belongs to the latter case, losing completely both the external and the internal chitization, due to the secondary modification (Plate 2, fig. 11).

The metapleuron (Plate 2, fig. 5, et_3 and em_3) is directly adjacent cephalad to the mesoparascutella (ps_2) in the present thorax, due to the extraordinary development of the latter, instead of being adjacent to the mesopleuron as is usual in insects,

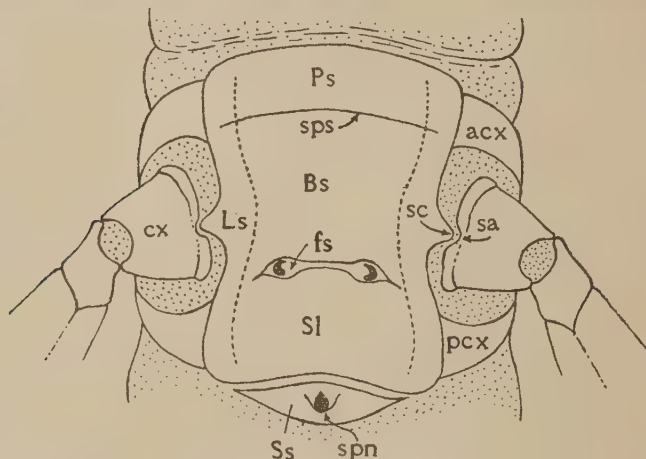


FIG. 3. Hypothetical definitive sternum. (Modified from Snodgrass, 1931.) *acx*, Precoxal bridge; *Bs*, basisternum; *cx*, coxa; *fs*, furcal suture; *Ls*, laterosternite; *pcx*, postcoxal bridge; *Ps*, presternum; *sa*, sternartia; *sc*, sternacolla; *Sl*, sternellum; *spn*, spinafurca; *sps*, secondary presternal suture; *Ss*, spinasternum.

although the position of the metapleuron remains normal. The relative position between the episternum and epimeron of this thoracic segment is almost normal. However, the episternum (et_3) is completely membranous, hence the metapleuron appears to be represented by the undivided pleural sclerite. The epimeron (em_3) is somewhat larger than the membranous episternum. This tendency, although distinctly shown in a rare case (*Dolichopus*), is not usual among the Diptera, where the development of these sclerites in size is reversed.

The metasternum (Plate 2, fig. 7, sm_3) is represented by a large sclerite that is homologous with the caudal elongated sclerite of the mesothorax. Although the shape of this sclerite

is different, the structures are very similar to those of the mesothorax. It differs only in the presence of the postcoxal bridges, which are completely wanting in the mesothorax. The sclerite homologous with the large presternum and the small basisternum of the mesothorax is completely reduced to a uniform membrane in the metathorax, hence a large membranous area persists between the two caudal chitinized sternal sclerites. As stated above, the chitinized metasternite, which is the only chitinized part of the metasternum, is a caudal half of the definitive sternum, and fundamentally different in the morphological significance from the undivided prothoracic sternum (*pst*), since the latter represents the whole of the definitive sternum.

The following is a summary of the principal conclusions derived from the study of the thoracic sclerotization of the Nymphomyiidae: (a) The peculiar general appearance of the thorax is chiefly due to the short but broad membranous condition of the cervix, the extreme elongation of the scutopræscutum and the mesascutella, the loose arrangement of the large sternal sclerites, the rudimental condition of the pleuron and the sternum, and the extreme development of the parascutellæ. (b) The sclerotization of the notum coincides well with that of the general dipterous thorax. (c) The wide space between the middle and hind legs and the displacement of the mesopleural sclerites are both probably connected directly with the anomalous expansion of the parascutellæ. (d) The extreme development of the sternal sclerites is thought to be chiefly due to the rudimental condition of the pleura, and has resulted in the anomalous lateral position of the forelegs. (e) The loose arrangement of the sternal sclerites is considered to be due partially to the secondary reduction of the preëxisting sclerites and partially to the rudimentary condition of the adjacent sclerites. (f) Although the sternal sclerotization appears to be very primitive, it is not sufficiently primitive to be compared with that of the nymphal forms or lower orders. It probably represents the most primitive condition among the known dipterous insects. (g) The nonangulated pleural suture supports the assumption that this insect belongs to the nematoceros Diptera. From the primitive character of the sternal and pleural sclerites this family seems to be placed in a comparatively low phylogenetic position in the Nematocera, but the characteristic modification of the various sclerites suggests that this insect may be far

more advanced than the hypothetical ancestors of Diptera, and represents a specialized family isolated from all other known dipterous groups.

Although in the previous report (1932) the thoracic spiracles were stated to be absent, further study has brought to light very minute, porelike, paired punctures (Plate 4, figs. 11 and 13, *sp*), about $2.5\ \mu$ in diameter, situated at the position where the spiracles would be expected. These punctures are very much smaller than the true spiracles of the Psychodidæ and allied insects, which are known to have extremely small thoracic spiracles for the dipterous insects. The external structures, such as the peritreme and related thickenings normally associated with the spiracles, have not been detected in the study of the punctures under consideration, and it is highly questionable whether they are functionally open.

THE WINGS

The shape of the wings is very diverse among the Diptera. Elongation and narrowing frequently occur synchronously with the elongation and narrowing of the body and various appendages, and this relationship is most commonly found in the following Nematocera: The Tipulidæ, Dixidæ, Culicidæ, and Chironomidæ. The higher groups are usually provided with broad wings proportional to the massive body but rarely elongated. Narrow wings are shown in the following slender flies: The Leptogastrinæ and *Dioctria* (Asilidæ), Systropinæ (Bombyliidæ), Xylophaginæ (Leptidæ), *Nerius* and *Calobata* (Micropezidæ), and *Baccha* (Syrphidæ). These features of the wings are derived from the reduction of the caudal area, squama, and alulæ, if present, of the wing membrane. As the result of these reductions the caudoproximal margin of the wing¹³ becomes more or less straight and nearly parallel to the anal or cubital vein, as shown in the wings of certain *Systropus* (Bombyliidæ), *Euglochina* (Tipulidæ), and *Stempellina* (Chironomidæ). Also in the Nymphomyiidæ the elongation and the narrowing of the wings well coincide with the above process of the reduction. However, the following features of the wing shape seem to be

¹³ In certain Hymenoptera, Homoptera, and Lepidoptera the forewings become very narrow and straight at the caudal margin, losing the large anal lobes. This is due to the development of a special structure that fastens together the two wings on one side for the synchronous wing action. Thus the reduction and narrowing of the forewings of these insects are somewhat different in significance from those of the dipterous wings.

quite characteristic for the present insect; namely, the extreme reduction of the squamal area and the sharply angulated or pointed wing tip, since in those dipterous insects provided with elongated wing the distal area, distad of the cord veins, is usually blunt or round, and the squama remains normal for the family or genus to which they belong.

The long setal fringe of the wings is another characteristic structure of the present insect. The wings of the insects, as a rule, are more or less fringed with hairs, but they are usually inconspicuous and very short in proportion to the size of the wings. The long hairy or scaly fringe is never found irregularly or at random, but its occurrence is limited to the following groups: The order Thysanoptera; certain parasitic Hymenoptera, the Trichogrammidæ and Mymaridæ; small Coleoptera, the Ptiliidæ; and tineinid Lepidoptera, the Gelechiidæ, Cosmopterygidæ, Elachistidæ, Heliodinidæ, Gracilaridæ, Lyonetiidæ, Coleophoridæ, etc. Among the dipterous groups the fringe, although far shorter than in the above insects, is found in the Culicidæ, Psychodidæ, Ceratopogonidæ (*Culicoides*, *Forcipomyia*, *Atrichopogon*, *Lasiohelea*, and *Dasyhelea*), Cecidomyiidæ (*Bryocrypta*, *Dicroneurus*, *Holoneurus*, *Diallactes*, *Winnertzia*, and *Monodiplosis*), and Chironomidæ (*Zavrelia*, *Lauterborniella*, *Polypedilum*, *Tanytarsus*, *Stempellina*, *Metriocnemus*, and *Cardiocladius*). Of the above dipterous groups the development of the wing fringe of the first three families is closely associated with the development of the common setæ or scales of the wing membrane, and no special differentiation, in size or structure, is shown between the setæ on the fringe and those on the membrane. In the last two families, although the fringes are not so conspicuous when compared with the extreme development of the marginal setæ of the present insect, they show more or less special differentiation as an independent structure, the common hairs (both the micro- and macrotrichia) of the membrane being completely or highly reduced, both in structure and in distribution.

In general the long setal fringes are well developed in the wings of minute insects, as mentioned above; the length is usually about or less than 2 to 3 millimeters in dipterous flies; 2 to 3 millimeters in thrips, except certain tubuliferid thrips, which rarely reach 7 millimeters in body length; less than 2 millimeters in chalcid flies, which include probably the smallest hymenopterous insects (0.21 millimeter in body length); and ptiliid or trichopterygid beetles, which contain the smallest known

beetles, ranging down to 0.2 millimeter. Among the Lepidoptera the long fringes are found in forms larger than in other orders, about 8 millimeters or less in body length, but as their designation, Microlepidoptera, signifies, these moths are small compared with lepidopterous insects in general. Furthermore, the setal fringes are the better developed the narrower the wings; they are best exhibited in small tineinid moths. For example, among the Yponomeutidæ, Plutellidæ, Glyphipterygidæ, and Tischeriidæ, species of the narrower-winged genera *Argyrestia*, *Plutella*, *Lamprystica*, *Glyphipteryx*, and *Tischeria* are usually provided with longer fringes than species of the broader-winged genera, *Yponomeuta*, *Ethmia*, *Cerostoma*, *Nipponympha*, *Imma*, *Tortyra*, *Simaethis*, *Brenthia*, *Choreutis*, and *Solenobia*. In the fissured wings, like those of the Pterophoridae and Orneodidæ, the marginal fringes are also highly developed, but in the same family the genus *Ochyrotica*, which has nonfissured massive wings, has shorter wing fringes than the other fissured-winged genera. Among the Diptera this tendency, although not so conspicuous as among the lepidopterous insects, is also exhibited among the Chironomidæ; the wing areas in the genus *Tanytarsus* are reduced in various degrees in different subgenera; for example, species in *Stempellina* and *Zavrella*, which are provided with rather narrow reduced wings that have better-developed marginal setæ than those in other subgenera, such as *Micropsectra*, *Tanytarsus*, and *Lundströmia*, which are provided with rather broad wings. Moreover, this tendency is shown even among species of the same subgenus; for example, in the subgenera *Stempellina* and *Smitta*, *St. cuneipennis* Edwards, *St. brevis* Edwards, *Sm. angusta* Edwards, etc., which have the characteristic narrow wings, are provided with longer setal fringes than the broad wings of other species of the respective subgenera.

The facts that the long setal fringes are well developed in minute narrow-winged insects, "microes," which are feeble flyers, and that they are never found among large active broad-winged insects, which are swift flyers, suggest that the function of these long fringes is to increase the buoyancy of the insect in the air; that is, to increase the soaring coefficient, as suggested and demonstrated by V. N. Chitrovo (1914) and C. W. Collins (1915) in their studies of plant seeds and the gipsy-moth larvæ, respectively, rather than to increase the efficiency of the wings as propelling organs by compensating for the reduced wing area.

The wing venation of this insect reveals a condition of high specialization, which is in accord with the degree of development of other structural features. Among the Diptera the venation of the Tipuloidea and Psychodoidea represents a primitive stage, while that of the Chironomidae, Ceratopogonidae, Simuliidae, Cyrtidae, Phoridae, Hippoboscidae, etc., is more specialized, in that the cephalization and the thickening of the veins have taken place in varying degrees. The latter group of dipterous insects is generally recognized, as a whole, as more specialized than the protonematoceros group, which is provided with the tipuloid or psychodoid venation. Viewed from this standpoint, the proximocephalic concentration of cephalic veins and the reduction of caudal veins of this insect suggest that the species under consideration is fairly high in the evolutionary scale and quite advanced in its own direction of specialization.

The presence of the well-developed ambient vein (veinlike structure of the wing margin) in the wing of this insect is one of the peculiar features common to the Nematocera in general. The ambient vein is considered homologous with the "ring vein" of the Thysanoptera and develops quite often in connection with the wing fringe, compensating possibly for the reduction of wing veins.

The entire proximal group of veins of the present wing ends on the costal margin. Among the dipterous insects the veins that end on the costal margin are either the subcostal or the radial veins or both. The subcosta often becomes very short or even completely atrophied, and more rarely coalesces with the radial vein; if present, it is generally retained as an independent vein. In the present wing the double nature at the proximal part of the costal margin shows that this portion consists of the costa coalesced with the subcosta. This feature of the coalescence is peculiar, not only in the Diptera but also in the other orders, since the subcosta, as mentioned above, usually coalesces with the radial vein instead of the costa, as shown in the forewings of certain Hymenoptera and Homoptera, and in the hind wings of the heteroneurous Lepidoptera in general and certain Neuroptera. The similar or related features are occasionally found in other orders, such as the Jassidae (*Gypona*) and Psyllidae (*Psylla*), and also in certain ichneumonoid Hymenoptera, the Ichneumonidae and the Braconidae, where the condition of $C + Sc + R$ obtains.

The radial vein is the most stable wing vein and is distinct even in such highly reduced venation as that of the Embioptera (*Oligotoma*), Thysanoptera, Homoptera (both sexes of the Aleurodidæ and males of the Coccidæ), and Diptera (Cecidomyiidae, Simuliidae, and Phoridae). Moreover, the radius of the generalized wing is provided with a definite branch, the radial sector; among the Diptera this sector, although subdivided into from two to four branches, is always more or less angulately branched off from the straight stem from which R_1 extends straight forward. On the basis of these general characters of the radial vein—the characteristic position, its constancy, and the feature of branching—the second cephalic group of veins of the present insect are likely to be homologous with the radial vein and its derivatives.

Of this radial group of the present insect the cephalic straight vein is evidently homologous with the first branch of the radius, but it is questionable whether the caudal branch is homologous with the radial sector itself or with vein R_{4+5} . The two-branched condition of the radial sector is universally found throughout both the orthorrhaphous and cyclorrhaphous groups of the Diptera. These two branches, R_{2+3} and R_{4+5} , are definitely present, however reduced the other veins may be, among members of the higher dipterous groups, but very rarely among the Nematocera R_{2+3} degenerates in situ into a very feeble obscure vein, although not completely obsolete, as shown in the Chironomidae. However, the simple condition of the radial sector is frequently found among the Orthorrhapha, such as the Ceratopogonidae, Simuliidae (excepted *Prosimulium*), Cecidomyiidae, Mycetophilidae (Sciarinae and Mycetophilinae), and Cyrtidae. This simple condition is derived from the unbranched R_s or from the distal coalescence of veins R_{2+3} and R_{4+5} . Therefore, the cephalic and caudal veins of the radial group of the Nymphomyiidae should be designated as R_1 and R_s , respectively. In my previous taxonomic report the latter vein was mentioned as R_{4+5} , R_{2+3} having been considered to be completely atrophied.

The most caudal vein of the present fly may be homologous with either the cubital or the anal vein when considered in connection with its position. However, when the reduction occurs in the anal area of the wing, the anal veins atrophy at first and the cubital veins remain more or less stable, as shown in the wings of certain Termitidae, Oligotomidae, Zorotypidae, Thysanoptera, Aphididae, and Aleurodidæ. The opposite case is

not definitely known. This tendency is also found in the dipterous groups that have the reduced anal lobes, like certain Systopinae, or have reduced venation, like the Mycetophilidae, Cecidomyiidae, and Cyrtidae. Moreover, the comparatively broad nature of the present vein, although it is not sharp and strong, is another important character for the suggestion of homology with the cubital vein, since the two cubital veins, Cu_1 and Cu_2 , always lie in a close parallel position, apparently forming one broad strong vein in the general dipterous wings. In this sense the most caudal vein of the Nymphomyiidae may have been derived mainly from the coalescence of the two cubital veins, Cu_1 and Cu_2 .

The median veins of wings are the most unstable veins, being frequently reduced or degenerated highly or completely, as we see in the wings of the Embioptera, Thysanoptera, and certain oligoneurous Homoptera and Diptera. This feebleness and the characteristic position between the radius and cubitus suggest

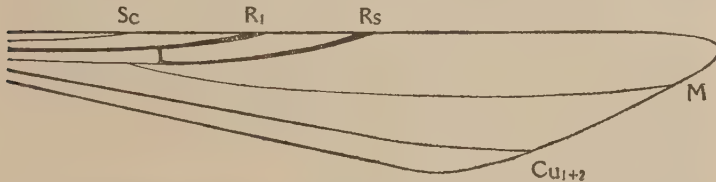


FIG. 4. Hypothetical venation. Sc, Subcosta; R_1 , first branch of radius; Rs, radial sector; M, media; Cu, cubitus.

that the creaselike vein of the present insect may be homologous with the vein media, unless it is derived from the folds as in the Blepharoceridae and Deuterophlebiidae. Whether this vein represents the unbranched media itself or either vein M_{1+2} or M_{3+4} , is highly problematic, since both conditions are found even in the same dipterous group.

The hypothetical wing venation of the present fly is shown in text fig. 4. It distinctly shows the nematocerous characters in the following points; namely, the median cell and the closed cell Cu_1 are wanting. Among the nematocerous wings there are two types of venation, the protonematocerous and eunematocerous types. In the former type the differentiation of the veins is very poor, and the radius and media are provided with many branches, as in the wings of the Psychodoidea (Tanyderidae, Ptychopteridae, and Psychodidae) and Tipuloidea (Trichoceridae

and Tipulidæ), while in the latter type the wing venation is more differentiated and the radial and median veins are provided with only a few branches, as shown in the Chironomoidea, Bibionoidea, Mycetophiloidea, etc. In this respect the present venation appears more closely similar to that of the Eunematocera than to that of the Protonematocera. Certain genera of the Cecidomyiidæ, Mycetophilidæ, and Chironomidæ show a reduction of the wing veins similar to that of the Nymphomyiidæ in the simple condition of the radial sector, the median, and the cubital vein.¹⁴

The wing base is very difficult to study, because the small sclerites are easily shifted from their normal positions and assume very different appearances. This is especially true in the case of minute flies, such as the present species. On the panorpoid wings the basal sclerites are generally well developed and their typical arrangement is well shown on the mecopterous wings. In the Diptera their arrangement and development are more or less modified, but those of the Tipuloidea are almost typical, as shown by Snodgrass (1909), Crampton (1919), and myself (1930). These sclerites of the present insect are greatly reduced, both in size and in number, being correlated with its feeble flying habit. Their arrangement and structure, however, suggest that they still allow the dorsoventral fluttering motion of the wing.

Of these basal sclerites the tegula is usually highly developed in the Diptera, Hymenoptera, Lepidoptera, and Mecoptera, and this sclerite is shown even on the base of the dipterous haltere. In the case of the Nymphomyiidæ it is vestigial and far removed from the tip of the costalis (Plate 4, fig. 13, te_2).

Of the five aliferæ the pleuralifera or the pleural wing process always persists on the thorax of the Pterygota and consists of a prominent pillarlike projection of the pleuron, which is divided into two parts by the pleural suture. But in the dip-

¹⁴ The cubital forks, which are formed by the anastomosis of two adjacent veins, M_{3+4} and Cu_1 , usually persist on the wings of the Eunematocera; however, they are frequently reduced into a simple condition of Cu_1 as in the present venation, either by the complete reduction of the cephalic branch, M_{3+4} , as in certain Mycetophilidæ (*Monoclona*, *Acnemia*, *Azana*, *Zygomyia*, and *Sceptonia*) and Cecidomyiidæ (*Holoneura*, *Miaster*, *Trisopsis* and *Diallactes*) or by the incomplete anastomosis or by the reduction of the crossvein, $m-cu$, as in the general Simuliidæ, certain Mycetophilidæ (*Ectrepesthoneura*, *Plastosciara* and *Sciara*) and Cecidomyidæ (*Winnertzia* and *Clinorhysis*).

terous pterothorax the above original condition of this alifera is more or less modified by a partial reduction of the episternal or epimeral sclerites as well as by the additional development of the secondary sclerite, the subalifera (Crampton). In the case of the simplest modification the pleuralifera is represented only by either the episternal region, losing the caudal half, as in the Dixidæ and Tanyderidæ; or the epimeral region, losing the cephalic half, as in the Blepharoceridæ and Limnobiinæ (Tipulidæ). A higher modification, which is very common among the Nematocera, occurs by the addition of the subalifera in the position of the episternal region of the pleuralifera. In the highest modification the pleuralifera is entirely represented by the subalifera itself, completely losing the epimeral region. In this state the pleuralifera is completely separated from the pleuron and exhibits an independent islandlike structure similar to the other aliferae freely located on the pleurotaxis, as shown in the Anisopodidæ, Leptidæ, Thaumaleidæ, etc. From the above morphological point of view the independent pleuralifera (Plate 4, fig. 13, *pr*) of the present insect must no doubt be included in the last category.

Of the other aliferae the most caudal micralifera is always wanting or fused with the postalifera in the higher Pterygota, and it is also wanting in the present insect. The three independent aliferae (the pre-, med-, and postalifera) are always present in the Pterygota, and the largest of the three is provided with a large ental disc, which serves as an attachment of the wing muscles. This largest alifera is not limited to the specific sclerite, but is represented by either of the above three aliferae. This ental disc, the pronator disc (Amans), is usually present on the medalifera in the Coleoptera, Lepidoptera, and Hymenoptera, while in the Diptera it is largest on the postalifera, as I have already pointed out in the study of a certain crane fly (1930). Although the medalifera (Plate 4, fig. 13, *ml*) is highly modified into a thin membrane in the present insect, these three aliferae (*pal*, *ml*, and *pol*) can be distinguished as in the generalized Diptera, but the pronator disc is not developed on any of them. This simple condition of the postalifera also suggests that this fly is not an active flyer.

The pteraliae are classified into the following groups by MacGillivray (1923): The duritæ, funditæ, and venellæ. The duritæ, which are also known as the axillaries, hypothetically consist of four sclerites, the sigmoidea, submedia, terminalia,

and navicula. In the pterothorax of the Diptera the first sclerite is most strongly developed of the four, being provided with an ental disc to which the wing muscles are attached, and possessing a neck region against which the costalis is directly articulated; while in the present insect these duritæ are obsolete, being represented only by the terminalia (Plate 4, fig. 13, *t*). The costalis is here loosely articulated to the notal wing process (caudalaria?) accompanying a minute obscure sclerite, which may be either the reduced sigmoidea or submedia.

The funditæ, or median plates (Snodgrass), are very unstable sclerites, being easily reduced or united with the venellæ. In certain orders, Orthoptera, Coleoptera, Hemiptera, etc., these sclerites are always present, while in the Lepidoptera and Hymenoptera they are generally obscure or wanting, and when present they are represented by only one sclerite, the mediella, as in the lower Nematocera (*Limonia*). It must be noted here that the term "median ossicles or medipterales" used by Cramp-ton (1919) in the study on the wing-base sclerite of the Pan-neuroptera (Hymenoptera, Neuroptera, Mecoptera, Diptera, Trichoptera, and Lepidoptera) is somewhat different in meaning from the term "funditæ or median plates," since his "median ossicles" include the various duritæ other than the sigmoidea in addition to the true funditæ.

In the present wing three venellæ (Plate 4, fig. 13), costalis (*cs*), radialis (*ra*), and analis (*as*), are distinctly present as in the generalized wing base, and these structures are highly thickened as compared with the other reduced pteralæ. Their arrangement and relationship to the wing veins have provided important evidence for the homology of the wing venation.

It is very peculiar that the wings of this fly are deciduous, being easily broken off along a definite line, as is commonly known in the Isoptera and Formicidæ. Whether or not this is a normal occurrence in life is still problematic. The wing is especially thinned between the highly thickened venellæ and the wing stem, showing a suturelike line. When the wings break off along this line, the wing stumps resemble those of ants rather than the scapular shields of termites. Deciduous wings are rare among the Diptera, being known only in *Nymphomyia* and in the female of the parasitic fly *Ascodipteron* (Streblidæ), in which the remaining portion of the wing also consists mainly of the venellæ, as in *Nymphomyia*.

THE LEGS

Delicate and slender legs like those in the present insect are prevalent in the nematocerous group, but the relative length of the three pairs of this fly is not common in dipterous insects. Among the Diptera, as a rule, the hind legs are the longest and the middle shortest. Rarely the forelegs are the longest and the middle shortest, as in the Chironomidæ. In the present fly the forelegs are the longest and the hind shortest. Moreover, the legs usually become elongated, paralleling the slenderness of the abdomen, wings, and various external appendages, as is best exhibited in various families of the Nematocera. In the Nymphomyiidæ the legs are very small for the size of the insect or for its extremely elongated abdomen.

The elongated coxæ and trochanters of *Nymphomyia* are also unusual characters for the Diptera and rarely found in the nematocerous group. The elongation of the coxæ is most distinctly shown in the archaic psychodoid forms, such as *Brucomyia* and *Nemopalpus*, which probably belong to the oldest existing types of Diptera. The Mycetophilidæ (excepting the Sciarinæ) are also provided with elongated coxæ. This family, although belonging to the eunematocerous group, retains many ancestral or primitive characters in certain structures of the antennæ, the thorax, and, especially, the legs, which suggests that it is intermediate between the other panorpoid groups (Mecoptera, Trichoptera, and Lepidoptera) and the Diptera. The elongation of the coxæ is also found in the forelegs of other archaic Nematocera, the Rhyphidæ (Anisopodidæ or Anisopidæ), which retain many structures related to the older fossil Mecoptera, and it is assumed that the Eunematocera, Brachycera, and other higher Diptera have descended from a common rhyphidlike ancestor. The elongation of the coxæ is usually found in archaic dipterous forms, which suggests the probability that they are more primitive phylogenetically than those that are shorter.¹⁵

¹⁵ The coxæ often appear superficially to be distinctly elongated in the lateral aspect on account of the following modification: The lateral sides of the coxæ become extended triangularly dorsad (Nematocera) or dorso-laterad (Brachycera and others), whereby the coxacoilæ and artes are found at about the middle in height of the thorax, while the mesal sides remain in the original short condition. Thus this superficial elongation is due to the secondary deformation of the coxæ and need not be discussed here.

Although very rare in the Diptera, the secondary elongation of the coxæ may occur along the line of specialization in connection with the high modification of the other structures of the legs. It is best exhibited in certain remarkable genera of the higher Nematocera, such as *Canthyloscelis* and *Corynoscelis* (both Scatopsidæ) and in the highly specialized grasping legs (forelegs) of the Ephyridiæ.

Each coxa of this fly presents a well-marked basal rim set off by a narrow submarginal membranous ring. This basal rim is homologous with the basicoxite of the generalized legs of insects, and the coxal muscles directly start from this rim, not being provided with special apodemal discs (promotors and remotors). The narrow membranous ring is homologous with the basicostal suture (Snodgrass). In the lower primitive orders (Orthopteroidea) this suture internally forms a strong basicosta, while in the higher orders it is very much obscured or entirely wanting. Among the Panorpoidea this suture is usually very much obscured or completely atrophied, although it is always present in Trichoptera, at least on the mesocoxa. In the Diptera this suture is almost always completely wanting. It is very strange that in spite of this the present fly is exceptionally provided with this suture on the coxa of each leg.

The coxa of the pterothorax, as a rule, is subdivided into two parts, the eucoxa (veracoxa or coxa genuina) and meron. In the Panorpoidea generally this feature is distinctly shown in its primitive condition, but only the Diptera show a complex modification on this point. The subdivision of the dipterous coxa very rarely shows the primitive orthopterous type in which the coxal suture or alasuture longitudinally extends throughout the coxa from the trochacoila to the coxartis. This is exhibited by *Pedicia* (Young) and *Limonia* (Tokunaga), in the lowest family, the Tipulidæ. Large members of the nematocerous group show the more or less modified coxal subdivision similar in appearance to that of the Mecoptera, where the coxal suture extends parabolically on one side of the coxa. Thus the proximal margin of the coxa consists of the two sclerites, the eucoxa and meron, but the distal margin is represented by the eucoxa alone. Further along this line of modification, the meron migrates dorsad, intruding onto the pleural region, and at last this sclerite becomes completely fused with the epimeron or sternepimeron, forming the meropleurite or merosternepleuron. Thus the first segment of the leg is represented solely by the eucoxa,

exhibiting an appearance similar to the procoxa, which is not differentiated into the two sclerites. This condition is best exhibited among certain special Nematocera; such as, the Psychodidæ, Blepharoceridæ, Deuterophlebiidæ, Tanyderidæ, and Ptychopteridæ, and the other higher groups, such as the Brachycera¹⁶ and Cyclorrhapha. Often the meron is reduced to a uniform membrane, as in certain chironomid, ceratopogonid, mycetophilid, and cecidomyiid flies. In this reduced state of the meron the coxa appears somewhat similar in structure to the primitive undivided condition as well as in the most highly modified form, since the coxa is represented by one chitinized sclerite, the eucoxa, alone. Of these types of modification the mesocoxæ of the present fly are likely to belong to the last category because of the presence of the large membranous area around the base of the coxa, which may be homologous with the meron, and not due to the undivided nature of the coxæ. Thus the mesocoxæ of this fly must be quite different in constitution from the procoxæ, although they resemble closely in appearance those of the prothorax.

The metacoxa of the Diptera, as a whole, is not subdivided superficially, while in the related orders, Trichoptera, Mecoptera, and Lepidoptera, all the metacoxæ are distinctly subdivided into the two sclerites as well as in the mesocoxæ. Whether the metacoxa here is undivided as in the procoxæ or represented by the eucoxa alone as in the mesocoxa of certain dipterous insects, is quite problematic.

The trochantin is rarely found in the Diptera, and it is commonly said that the legs of Diptera are directly articulated to the thorax without the intermediate sclerites. I have pointed out an exception in the case of the Tipulidæ where this sclerite is present in a highly reduced semichitinous state. In the subject of this paper the sclerite is lacking.

The trochanters of the dipterous legs generally are very short, small, and somewhat triangular in outline, no matter how the legs and coxæ may be elongated, as in the crane flies and fungus gnats. In the present fly all the trochanters are very long and cylindrical. Moreover, each trochanter is firmly fused with the proximal subdivision of the femur along the immovable femasure. This fused part moves as if it were one segment, being

¹⁶ According to Young (1921) the female of a certain midaid fly, *Midas clavatus*, is exceptional in being provided with the independent meron.

demarked by the trochacoria and the secondary membranous ring of the femur at each end, and is not provided with muscles, which suggests the absence of movement at the femasuture. This immovable trochafemoral union is widely found in various insects, even in the more primitive orders, as in the Thysanura, but it is most prevalent in the higher orders, although in all of these cases the trochanters and femora are fused into one segment, while in *Nymphomyia* the membranous ring of the femur subdivides it into the proximal part, which consists of the trochanter and the proximal end of the femur, and the distal part, which represents the large distal region of the femur.

The dipterous femur usually is simply elongated and somewhat flattened in its cephalocaudal diameter and subdivided femora, like those in *Nymphomyia*, are rarely found among the Diptera. They are only known in the highly specialized parasitic flies, the Nycteribiidæ, and in the Deuterophlebiidæ (female).¹⁷

On the tibiæ of this fly are also subdivisions similar to those in the femora, and they are equally rare. This pseudosegmental nature of the tibiæ is shown in spider flies as the tibial rings and more definite constrictions are found in many flies and caddice-fly larvæ.¹⁸

The above discussion on the subdivisions of the femora and tibiæ leads to the conclusion that the pseudosegmental feature in the present insect may result from the mechanical necessity

¹⁷ In the latter case Pulikovsky, Trans. Ent. Soc. London (1924) 45-62, stated, after examining a female adult, which was extracted from the pupal skin, that the trochanter consists of two joints, but I confirmed by observations on females, both the pupal and emerged adult, that the so-called second trochanter is nothing but a part of the femur, which is partially constricted or subdivided on the dorsal side by a semicircular membranous area. At this membrane the leg in the pupal skin is bent sharply as if it were a true segment, but in the fully extended leg of the free-living imago it reveals a structure similar to that of *Nymphomyia*. Thus, unisegmental trochanters are the rule among the Diptera, and the true plurisegmental nature, which is found in certain limited groups (for example, Odonata and Symphyta and certain parasitic Hymenoptera), is never found among the Diptera.

¹⁸ Among the Arachnoidea there is a large segment, the patella, between the femur and tibia, and in a few insects this segment is found as a small intersegmental sclerite, as I have stated in the case of a certain crane fly. Research on the homology between the patella and the proximal subdivision of the tibia and also on that between the second trochanter and the proximal subdivision of the femur, at least in dipterous legs, failed to reveal any relation between the two, respectively.

of providing flexibility to the segment by secondary division or reduction.

The accessory structures of the tarsal claws, such as the pulvilli and empodium, are of considerable importance for classificatory purposes, since they are constantly present in dipterous insects. In the Cyclorrhapha the two padlike pulvilli are always present, although the padlike empodium sometimes is reduced to a bristlelike form. In the Brachycera¹⁹ of the superfamily Eremochæta, as a rule, both the pulvilli and empodium are padlike in structure, while the rest of this series is provided with two padlike pulvilli and one bristlelike empodium. In the Nematocera certain families, such as the Bibionidæ and Rhyphidæ, are usually provided with well-developed pulvilli and empodium similar to the Eremochæta, but in the great majority of this series two pulvilli are completely wanting or vestigial, although a single padlike empodium is retained. Thus, both the absence of the two pulvilli and the presence of the single padlike empodium of the Nymphomyiidæ offer strong evidence that this fly belongs in the series Nematocera.

THE ABDOMEN

The abdominal segments of the insect are divided into three groups; namely, pregenital, genital, and postgenital. The first term is applied to the cephalic seven abdominal segments, which contain most of the visceral organs. The second consists of the eighth and ninth segments, which are highly modified generally on account of the adaptive structures for copulation and oviposition. The last term is used for the segments beyond the ninth, which are greatly reduced and fused with each other.

THE PREGENITAL SEGMENTS

The pregenital segments (common abdominal segments, visceral segments of Snodgrass) of the Diptera are modified and reduced in various degrees according to the taxonomic groups. In the higher groups they are reduced to five or less, while in the nematoceros group there are seven, which are typical and show

¹⁹ Verall, G. H., *British Flies*. London 5 (1909) 14-47, arranged the brachycerous flies as follows: Eremochæta (Stratiomyidæ, Acanthomeridæ, Leptidæ, Tabanidæ, Nemestrinidæ, and Cyrtidæ), Tromoptera (Bombyliidæ and Therevidæ), Dermatina (Scenopinidæ and Mydæidæ), Eriogonopoda (Apioceridæ and Asilidæ), Microphona (Empidæ and Dolichopodidæ), Acroptera (Lonchopteridæ), and Hypocera (Phoridæ).

no special differentiation in either sex, as in the species under consideration. In the brachycerous group they show transitional forms between the above two groups, and the number of the nonmodified abdominal segments is variable according to taxonomic division and sex, but tolerably constant within the limits of most of the families. Among the brachycerous insects the hypothetical number of the nonmodified segments is shown in a few families, such as the Leptidæ, Asilidæ, Empidæ, Scenopidæ, and Mydaidæ. In the majority of other families one, two, or more posterior abdominal segments are reduced and modified into the telescopic or concealed genital segments. The significance of the reduction and modification of the abdominal segments is apt to be overlooked, but it must have some phylogenetic importance when taken in connection with the study of the genital segments.

The seven segments of this region as a rule are simple in structure, and in the Nematocera differ but little from one another either in shape or size. The first segment is more subject to modification than is any other. The first segment of the Diptera is somewhat different in size from the adjacent abdominal segment; and, as Young has pointed out, there is a tendency for the first tergum, as well as the corresponding sternum, to decrease in relative size. Usually the first segment is smaller than the second, and this is best exhibited in the higher Diptera. In the lower Diptera, such as the Chironomidea, Tipuloidea, Psychodoidea, and Culicoidea, the first segment is usually very large but not larger than the second, while in the present fly the first segment, especially its tergum, is unusually large and larger than the second. Moreover, this large segment of *Nymphomyia*, as in the general Orthorrhapha, is never due to the fusion with the second segment, which is quite common throughout the Cyclorrhapha.²⁰

²⁰ There has been reported a secondary suture of the first abdominal tergum named the "adventitious suture" by Young (1921) who stated that this suture "was found in all the species examined among both the Calyptrata and the Acalyptrata. Generally speaking this suture is less developed in the calyptrate than in the acalyptrate muscids, etc." But I am not yet certain whether or not the presence or absence of this suture is an important definite mark of distinction between the Cyclorrhapha and the Orthorrhapha, since in certain nematocerous insects, e. g. chironomid flies—similar thickenings are found, although their homology with the adventitious suture remains to be elucidated (Tokunaga, 1932).

In homologizing the sclerites or divisions throughout the abdominal segments, the position of the spiracles is an invaluable guide, but unfortunately in *Nymphomyia* the abdominal spiracles are completely lacking, and the sclerites are also greatly reduced into a common membrane, thus obliterating the usual abdominal divisions. In the case of this fly the lateral groove (text fig. 5, $x-x$) is the only mark by which the divisions of the abdominal segments can be determined. This groove is distinct in the larvæ of holometabolous insects, extending along each side of the body throughout the abdomen and the thorax below the line of the spiracles. It is named the "dorso-pleural" or "tergo-pleural groove" by Snodgrass (1931), the "sterno-pleural suture" by Craighead (1916), the "ventro-lateral suture" by Böving (1914), and the "pleural suture" by Hopkins (1909). As shown by the names applied, the morphologic significance of this groove is differently stated by each of these writers, but I intend to employ the name "tergo-pleural groove" given by Snodgrass, because of the following facts: (a) In the thoracic region this groove extends between the paratergite, which is the lateral sclerite of the tergum or the allied region, and the subcoxa, which is homologous with the pleuron; and (b) on the genital segments this groove is between the paratergite or allied region and the common limb base of the stylus and gonapophysis, which is also homologous with the thoracic pleuron.

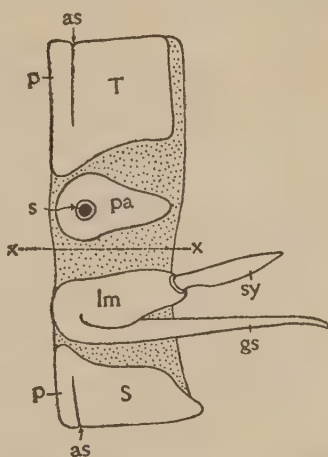


FIG. 5. Diagram of the theoretical abdominal segment. (Modified from Snodgrass, 1931.) *as*, Antecostal suture; *gs*, gonapophysis; *lm*, limb base or pleuron; *p*, precosta; *pa*, paratergite; *S*, sternum; *s*, spiracle; *sy*, stylus; *T*, tergum; $x-x$, tergo-pleural line.

In the present fly this tergo-pleural groove (text fig. 2, $Y-Y$) extends longitudinally below the lateral tubercle and the lateral transparent pattern, and is most distinctly shown in the state of contraction of the abdominal muscles. Besides this groove there is another very shallow groove (text fig. 2, $X-X$), which also extends longitudinally above the lateral tubercle or below

the dorsal group of the small tubercles. This shallow groove may be regarded as being derived from the dorsal attachments of the transversal lateral muscles, somewhat similar to the tergopleural groove. For this reason this groove is thought to be homologous with the paratergal suture. Thus we can distinguish in the abdominal segment of this fly the tergum (s. lat.) and the pleurosternum by the tergopleural groove. The tergum is subdivisible into the tergum (s. str.) and the paratergite by the paratergal groove, but the sternum and the pleuron cannot be delimited as they form a completely uniform membrane.

The tergum of *Nymphomyia* is not different in its essential structures from that of insects in general, being provided with the intersegmental membrane, precosta, and antecosta.

The pleurosternal region of this fly also differs but little in the essential structures from that of insects in general. The absence of distinct chitinization and differentiation of precosta and antecosta are the only results of reduction and modification, a condition not very significant since it is very prevalent in the higher orders, not only among the Diptera. Moreover, the distinction between the sclerotization of the pleuron²¹ and the sternum (primary sternum) is known in the lower Apterygota and immature forms alone (text fig. 5), whereas in the imagines of the higher Holometabola these two sclerites are completely fused with each other, or the pleuron is completely reduced to a membrane, or both are reduced to a common membrane, as in the present fly. In the latter case, therefore, the so-called "sternum" or "sternite" is either composed of the united pleuron and primary sternum or of the last sclerite alone.

The structure of the paratergal region of this fly is peculiar in the absence of the abdominal spiracle and the presence of the scleritelike tuberculate patch (text fig. 2, *lt*). The non-spiracle or apneustic condition of the dipterous abdomen has been reported by Edwards and Kemper for *Deuterophlebia mirabilis* and *Psychoda phalaenoides*, and this condition is very peculiar for the adult Diptera. The paratergal region of the Diptera generally is completely membranous where the spiracle is found. Sometimes the tergal plate is not divided into the

²¹ The pleuron of the abdominal segment is known as the "limb base" in the Apterygota and the campodeiform nymphs, and as the "subcoxa" in certain holometabolous eruciform larvæ (Coleoptera, Hymenoptera, and Lepidoptera).

tergum and paratergite and extends so far downward as to include the spiracles as seen in certain Cyclorrhapha (Tachinidæ, Muscidæ, Sarcophagidæ, Anthomyiidæ, etc.). While in the present form the scleritelike patch is present in the position where the spiracle would be expected. This external differentiation²² of the paratergal sclerotization is very unusual in the adult Holometabola, since it is found only in the immature forms of certain Coleoptera, Lepidoptera, and Hymenoptera. The origin of this patch, whether it is derived from the preëxistent paratergal sclerite of the larval stage or from the secondary chitinization in the imaginal stage, remains to be investigated.

THE GENITAL AND POSTGENITAL SEGMENTS

In the higher orders of insects, especially the Diptera, the genital and postgenital divisions are very obscure due to the secondary fusion, reduction, and modification for copulation and oviposition. The number of the genital segments is usually considered to be two, but that of the postgenital segments has received diverse interpretations by different authorities. There have been known two representative theories. One is the eleven-segment theory, in which the abdominal segments are counted as nine somites, together with the two postgenital somites, the tenth and eleventh (telson) somites, of which the cerci are the appendages of the tenth abdominal somite. The other is the twelve-segment theory, which is maintained embryologically by Heymons, Wheeler, Nelson, and others, and morphologically by Snodgrass, Imms, MacGillivray, and others, who recognize three postgenital somites, the tenth, eleventh, and twelfth, the cerci properly belonging to the eleventh somite, and the twelfth somite being sometimes known as the telson. On the whole, the balance of opinion inclines towards the latter theory. In the Diptera this primitive theoretical condition is not known to occur, since the posterior-most two, three, or more segments are usually fused with each other and become membranous. In the female of the Tipulidæ, however, the ninth, tenth, and cercus-bearing eleventh, abdominal segments may be distinguished as I reported in 1930, and the females of the Panorpidæ (Mecoptera) show similar abdominal segmentation.

Based on the positions of the genital aperture, anus, parameres, cerci, and cercariæ in the female and of the clasping

²² Internally the paratergal region is usually characterized in almost all insects by the presence of a special group of the paratergal muscles.

organs in the male, the following segmentation of the terminal region, as illustrated in text fig. 6, may be suggested for the present species.

The anterior genital segment of the female fly differs very much in structure from other Diptera in the presence of the characteristic lateral extension. This lateral extension (Plate 4, figs. 14 to 16; Plate 5, figs. 17 to 19, *pj*) is the specially modified tergopleural fold. Thus, the caudal extensions of this fold have no relation to the true appendages of limb bases, such as the styli and gonapophyses (text fig. 5, *sy* and *gs*), although they superficially assume a position proper for the typical genital appendages. The latter are greatly reduced, as in the general Diptera, and represented only by thickened parameres (text fig. 6, *gs*₁) guarding the aperture of the gonad in the innermost part of the genital chamber. Among the Diptera the typical gonapophyses and limb bases of the eighth abdominal segment are shown only in the females of the Tipulidæ; in all other Nematocera they are highly reduced, as in *Nymphomyia* or represented by small, paired, membranous lobes, which are known as the octavalvæ (Tokunaga, 1930 and 1932). In the Brachycera and Athericera these structures are completely atrophied. In the Nymphomyiidae the aperture of the gonad is typically situated between the eighth and ninth sterna, as in the general nematocerous insects, and has not migrated caudad as in the higher groups having telescopic ovipositors. Another modification of the eighth segment is the longitudinal ental thickening of the sternum. This thickening (Plate 4, fig. 16, *ec*) is developed secondarily for the attachment of the muscles related to the female genital organs.

In the male the eighth segment is as peculiar as in the female in the presence of the characteristic paratergal structures (Plate 5, figs. 17 to 19, *pj*), although they are different in shape from the latter. The essential sexual differences are the complete atrophy of the gonapophyses and the related appendages and the absence of both the sternal antecostal thickening and the secondary ental chitinization found in the female. Other fundamental structures of this segment are closely similar to those of the pregenital segment, as in the case of the female.

The ental thickenings of the genital and postgenital segment develop secondarily and sporadically in various regions in widely varying shapes among different groups (families, genera, or species) for mechanical reasons, and between opposite sexes according to the variation of the hypopygial structures. This

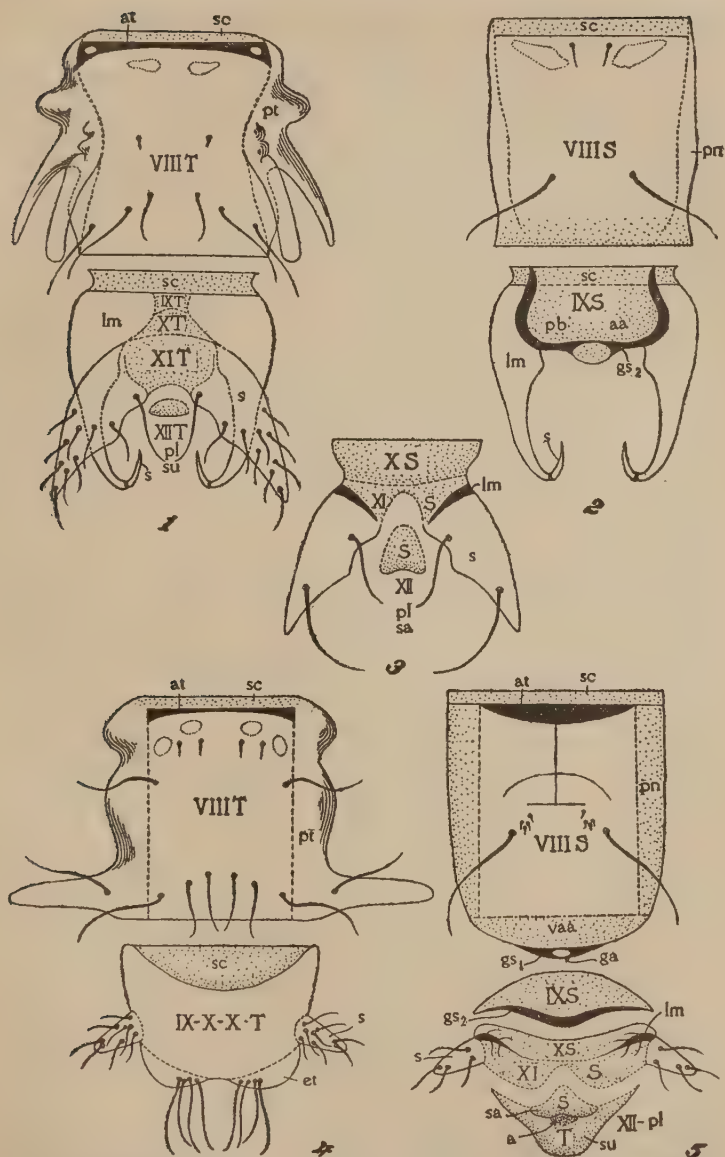


FIG. 6. Diagrams illustrating the concept of the structural plan of the terminal abdominal segments adopted in this paper. 1, Dorsal aspect, male; 2, ventral aspect, male; 3, ventral aspect of the postgenital segments, male; 4, dorsal aspect, female; 5, ventral aspect, female. a, Anus; aa, aedeagus; at, antecosta; ep, epiproct; ga, genital aperture; gs, gonapophysis or paramere; lm, limb base, coxite or cercaria; pb, pons basalis; pl, periproct; pn, pleuron; pt, paratergite; S, sternum; s, stylus or cercus; sc, lami subanalis; sc, segmacoria; su, lami supra-analis; t, tergum; vaa, ventral wall of genital chamber.

is best exhibited in the hypopygia of chironomid flies such as *Clunio*, *Tanytarsus*, and *Chironomus*.

In both sexes the paratergal projections are devoid of both the special musculature and the mechanism of articulation, indicating that they are merely a local elongation of the paratergal region and not the regular appendage. In the male sex the paratergal projection is movable dorsoventrad, but this is due to the contraction of the tergoventral muscles, which extend from the common basal plate (paratergite proper) of the projection to the sternum and are not due to the independent movement of the projection by itself.

The eighth segment of the male, as a whole, is not normally provided with genital appendages, no matter how highly it may be modified as in the concealed or retractile genital form of the higher Diptera. The *ædeagus* (*aa*) is found superficially just caudad of the eighth sternum in this insect, but it properly belongs to the next caudal segment as indicated by a deep membranous furrow formed by the segmacoria between it and the sternum.

In the great majority of dipterous insects, the genital ninth and postgenital somites in both sexes are highly modified from their original features and fused with each other, forming the so-called "terminal ninth abdominal segment." The tenth and twelfth segments, especially, are most unstable and reducible, and it is very difficult to identify them. In this highly modified and reduced condition the important marks are the persistent parameres, cerci, and various clasping organs, which show the location of their own segments. Even when the dorsum is represented by a completely fused sclerotization, they indicate some segmental divisions on the venter.

The dorsum of the terminal segment in the present female is uniformly thickened and there is no trace of segmentation, but the presence of paired cerci, which closely arise from the lateral sides of the dorsum, shows that the eleventh tergum is concerned with the formation of this dorsum. The ninth tergum may be considered either as reduced to a common membrane, forming a large segmacoria, or fused with the posterior terga, forming a common dorsum. In the present fly the latter seems to be the case, since the ninth tergum always remains last when the reduction of these segments occurs, and the eleventh tergum never remains alone without the coexistence

of the chitinization of the ninth tergum. Thus, the dorsum of the terminal segment is regarded as formed by the complete fusion of the ninth, tenth, and eleventh terga.

The venter of the female terminal segment is generally membranous and divisible into two regions by a transversal thickening, which is the second paramere (the first parameres are the paired sclerites of the eighth segment found at the genital aperture at the end of the eighth sternum). Thus, the dorsal wall of the genital chamber, cephalad of the second paramere, is the proper ninth sternum. The caudal region, caudad of this paramere, where the cercariæ, cerci, and blunt paraprocts are found, is formed by the fusion of the tenth and eleventh sterna and periproct. The periproct may be regarded as the remnant of the highly reduced twelfth somite. Thus, the venter of the female terminal segment is divisible into two or three regions; namely, the ninth sternum and the common venter of the postgenital sterna or the twelfth is further separated from the latter.

The terminal segment of the male carries large paired clasping organs, cerci, and unpaired ædeagus. The presence of these structures shows that this segment is formed by the fusion of the ninth and postgenital segments. The dorsum of this segment does not show segmentation, but the lateral sides possess slight constrictions that suggest the demarcation between the clasper-bearing ninth and the cercus-bearing eleventh segments. There can be little doubt, therefore, that the middorsal area is formed by the fusion of the proper ninth, tenth, and eleventh terga. The small area between the bases of the large cerci may be the remnant of the twelfth tergum, known as the lami supra-analis (*su*).

The venter of the male terminal segment is more distinctly divided into two regions than on the dorsum by the presence of the large ædeagus and the distinct cercariæ. The ædeagus is formed by the fusion of the median penis and the paired lateral parameres, which are homologous with the gonapophyses of the ninth segment. Thus, in the present fly it seems to be the caudal projection of the eighth sternum, but it properly belongs to the ninth segment, as already stated. The large pubescent area caudad of the ædeagus, where the cercariæ are located, may be the fused venter of the proper sterna of the tenth and eleventh segments. The most caudal small narrow

area between the bases of the cerci corresponds to the lami supra-analis (*su*) of the periproct (the twelfth somite) and is known as the lami subanalis (*sa*).

Usually the tenth abdominal somite of the Diptera is highly or completely atrophied in both sexes, but its location is frequently shown by the accessory genital apparatus apparently homologous with the gonapophyses and styli of the tenth somite. These apparatus generally are found concealed by the large claspings organs of the male. In certain Rhyphidæ, Culicidæ, Chironomidæ, etc., they are paired and situated close to the bases of the coxites of the claspings organs belonging to the ninth somite. In other families, such as the Blepharoceridæ, Psychodidæ, etc., they become unpaired, median, valvelike projections closely applied on the dorsal side of the ædeagus.

In the great majority of the Diptera the cerci superficially arise from the tenth somite and thereby the cercus-bearing segment is counted as the tenth, but this is due to the reduction of the true tenth somite. The cerci must belong to the eleventh abdominal somite, however, because of the retention of the appendages properly belonging to the tenth somite.

For these reasons, the twelve-segment theory is considered duly applicable to the dipterous abdominal segmentation as well as to that of the generalized insect.

To recapitulate the main points in the homology of the appendages of the terminal abdominal somites of the Nymphomyiidæ, the following may be stated. The lateral projections of the eighth somite in both sexes have no relation to the true pleural appendages, being paratergal in origin. The true appendages of the eighth somite remain as the first parameres in the female, while those of the male are completely atrophied. Those of the ninth somite of the female are also reduced to the second parameres. In the male they are highly developed, the limb bases and styli forming the large paired claspings organs and the gonapophyses taking part in the formation of the large ædeagus. The appendages of the tenth somite are completely atrophied in both sexes. The styli and limb bases of the eleventh somite in both sexes are homologous with the paired cerci and the paired cercariæ, respectively. The twelfth somite of each sex is reduced to the periproct (text fig. 6).

The hypopygial structures show wide divergence among the Diptera, and their phylogenetic affinities are very difficult to ascertain. Taken in connection with other structures, the fol-

lowing features as a whole are considered important in establishing the affinity of this fly to the nematoceros group: The nonmodified pregenital segments, the nontelesopic or non-concealed hypopygium of each sex, the comparatively simple structures of the male hypopygium, the large elongated cerci of the male located on the caudal end of the abdomen, the large elongated coxites situated laterally, the large exposed ædeagus, the absence of the chitinized ejaculatory filament, and the typical position of the genital apertures in both sexes.

PHYLOGENETIC CONSIDERATION

Although the family Nymphomyiidae possesses the brachycerous antennæ, it is considered as belonging to the Nematocera, on the strength of the following distinctive characters: Elongated head capsule, large occipital foramen, cylindrically elongated thorax, nonangulated mesopleural suture, nondifferentiated abdominal segments, exposed and comparatively simple structures of the genital segments and their appendages, large and prominent cerci of both sexes, absence of pulvilli, presence of empodium, and the nematoceros wing venation.

This family seems to stand on a comparatively low level in the Nematocera, because of the following thoracic structures:²³ The large pronotum, small pleuron, isolated and large sternum, and elongated coxæ. Other structures, large cerci, large coxites, and styles which are typically arranged, are also thought to be rather primitive characters for the Diptera. This consideration is supported anatomically by the presence of the nonconcentrated independent eight ganglia in the abdomen, as will be reported in a later contribution. However, when the antennal structures, the wing venation, reduced metanotum, fused terminal segments of the abdomen, modified eighth abdominal segment of both sexes, etc., are taken into consideration, this insect is not so low in position as to be compared with the protonematoceros insects or with the archaic ancestral Diptera. The weight of the various extraordinary characters of this insect, then, leads us to the conclusion that this species is a representative of an extremely specialized family isolated from all other groups of the Diptera.

²³ The thoracic sclerotization has a vastly more important significance for the consideration of phylogenetic affinity of the Diptera than other parts and various appendages, because of its comparative stability, as suggested by Crampton (1925 and 1926) and Tokunaga (1932).

SUMMARY

The conclusions derived from morphological study of the sclerotization of the nymphomyiid fly may be itemized as follows:

A. The chief characteristic modification of the head and mouth parts has occurred along the line of reduction of various structures and in the direction of cephalocaudal elongation of the head capsule as a whole.

1. The cephalocaudal arrangement of various organs, such as the antennæ, compound eyes, and ocelli, and also the prognathous type of the head, are intimately related to the elongation of the head capsule.

2. The head capsule consists of the vertex, frontoclypeus, occiput, and probably the antennariæ, stipites, and theca compactly fused together.

3. The occipital foramen is unusually large, which may be due to the prognathous head capsule.

4. The following homology of the peculiar projections of the head capsule may be shown:

Snoutlike projection. Frontoclypeal projection.

Visorlike projection. Cranial projection.

Labiumlike projection. Projection of the theca? or stipes?

5. The following structures of the fixed parts of the head are atrophied:

Exoskeletons.

Labrum-epipharynx.

Odontoideæ.

Other articular processes.

Endoskeletons.

Corpotentorium.

Laminitentorium.

Their tentorinæ.

Sutures.

Epicranial.

Distal part of the stem.

Arms.

Occipital.

Frontoclypeal, etc.

The proximal part of the epicranial stem alone remains as the middorsal suture on the dorsal part of the head.

6. The great majority of the mouth parts is highly reduced. The pharynx directly opens into the peculiar chitinized pocket-

like mouth concavity. Developmental states of the trophic organs are shown as follows:

Movable parts.

Retained.

Paraglossæ? (papilliform projection).

Atrophied.

Mandibles.

Maxillæ and appendages.

Labium and appendages.

Pharynx.

Retained.

Basipharynx.

Postpharynx. Oesophageal pump.

Salivary pump.

Atrophied.

Propharynx.

Epipharynx.

Tormæ.

Epigusta.

Parapharynx.

Hypopharynx.

Oscula.

Salivary sclerites.

7. The antennæ are of the brachycerous type and provided with the characteristic intersegmental sensillæ as in the larval antennæ of the Diptera. The constitution of the antenna is shown as follows:

Articulation.

Antennaria (probably fused with the adjacent sclerite of the head capsule).

Antacoria (very small).

Segmentation.

Scape (pyriform).

Pedice! (spherical).

Flagellum (3-segmented).

First segment (large and spoon-shaped).

Second segment (small and ring-shaped).

Intersegmental sensillæ (clavate and three in number).

Third segment (small and needle-shaped).

8. The compound eyes are of the holoptic type and characteristic in being contiguous on the ventral side while widely separated from one another on the dorsal side. They consist of the normal oculatæ and biconvex facets.

9. The ocelli are very large, laterally located, and two in number. They may be different in origin from the primitive ocelli

or primary ocelli, but more probably are derived from the lateral ocelli or larval eyespots.

10. The muscles are also reduced, and only twelve different muscles are contained within the head capsule.

B. All the sclerites of the cervix are completely degenerated. The cervix is broad but short and becomes as a whole uniformly membranous.

C. The thorax is highly different from the dipterous thorax in general, both in characteristic modification and in the rudimental condition of its sclerotization.

1. The notum of the prothorax is large and secondarily divided into the antenotum and postnotum, which are completely subdivided into paired lateral halves on the dorsomeson by the cephalic projection of the mesopræscutum and become located on the lateral side.

2. The mesonotum consists of the following sclerites:

Mesonotum.

Scutopræscutum.

Scutellum.

Scutulis.

Parascutules.

Postscutellum.

Mesascutella.

Parascutellæ.

Katapleurotergites? (parasternites).

The elongation of the thorax, on the dorsal side, is mainly due to the elongated scutopræscutum and postscutellum (mesascutella). The mesascutella deeply intrudes caudoentad and forms a large phragma, which is one of the two endoskeletons well developed in the thorax. The parascutella occupies almost the caudal half of the entire latas of the thorax, and its anomalous development affects the position of the mesoepimeral sclerites and also the relative position of the middle and hind legs.

3. The sclerites of the metanotum are completely reduced into a uniform membrane, being infolded between the mesothoracic sclerite and the cephalic margin of the first abdominal antecosta.

4. The development of the pleural sclerites is very poor. This may be partially due to the rudimental and membranous condition of the pleuron itself and also to the effect of the intrusion of the parascutella.

5. The pleuron is very small, being represented only by the episternal chitinization from which the procoxacoila is derived. The epimeral sclerites are completely atrophied.

6. The mesopleuron is comparatively small and its chitinization is very low in development. The pleural suture is not sharply angulated but slightly undulated. The episternal suture is obscure. The epimeral suture is completely obliterated by the cephalic intrusion of the parascutella along this suture. The displacement of the epimeral sclerites is chiefly due to the anomalous expansion of the parascutella.

7. The metapleuron is represented only by the epimeral chitinization, completely losing the episternal sclerites.

8. The coxacoilæ of the meso- and metathoracic segments are not developed.

9. The sternal sclerites are fully developed and loosely arranged, as shown in the thorax of certain immature forms or certain lower insects. Viewed from the evolutionary standpoint of the thoracic sclerotization of the Diptera, these sternal features, taken in connection with the rudimental condition of the pleuron, indicate that the thorax is in the primitive state of development. The elongation of the thorax, on the ventral side, is mainly related to the large sternal sclerites and their loose arrangement.

10. The constitution of the sternal sclerites is shown as follows:

Sternum.

Prosternum.

Undivided primary sternum.

Fused laterosternites.

Mesosternum.

Independent presternum.

Membranous basisternum.

Elongated sternellum.

Fused precoxal bridges.

Secondary chitinization? (parasternites).

Metasternum.

Basisternosternellum.

Fused laterosternites.

Fused pre- and postcoxal bridges.

Each sternum is provided with a pair of sternacoilæ which are derived from the laterosternites for the articulation of the coxæ. The postcoxal bridges of the mesosternum and the presternum of the metasternum are atrophied. The unusual lateral position of the procoxal articulation is related to the broad prosternum and the vestigial propleuron.

11. The thoracic endoskeletons are generally very low in development. Their relation to the external marks is shown as follows:

Position.	Phragma.	External mark.	Development, etc.
Pronotum	Phragmæ	Phragminæ	Wanting.
Propleuron	Pleuradema	Pleurademina	Obscure, along the pleural suture.
	Entopleuron		Obscure.
Prosternum	Furca	Furcina	Wanting.
	Furcella	Furcellina	Do.
	Prephragma	Prephragmina	Very large, along the cephalic margin of the præscutum.
	Paraphragma	Paraphragmina	Small, along the cephalic margin of the scutulis.
Mesonotum	Lateral phragma		Small, along the laterocaudal margin of the scutulis.
	Postphragma	Postphragmina	Very large, along the caudal margin of the mesascutella, fused with the metaprephragma.
	Caudal phragma		Narrow, along the caudal margin of the parascutella.
Mesopleuron	Pleuradema	Pleurademina	Obscure, along the pleural suture.
	Transversal phragma		Narrow, along the caudal margin of the presternum.
	Furca	Furcina	Small, along the transternal suture.
Mesosternum	Longitudinal phragma		Obscure, along the midventral suture, originated from the furca.
	Furcella	Furcellina	Obscure, along the pleural suture.
Metanotum	Prephragma	Prephragmina	United with the postphragma of the mesothorax.
Metapleuron	Phragma	Phragmina	Wanting.
	Furca	Furcina	Obscure, along the cephalic margin of the basisternosternellum.
Metasternum	Longitudinal phragma		Small, along the midventral suture, originated from the furca.

D. The legs are all slender but small for the size of the insect. The forelegs are the longest and the hind legs are the shortest.

1. The segmentation of the legs is shown as follows:

Morphological segmentation.	Subdivision.	Mechanical segmentation.				
Coxa.....	<table><tr><td>Coxal rim.....</td><td rowspan="3">} First segment.</td></tr><tr><td>Basicostal suture.</td></tr><tr><td>Coxa proper.....</td></tr></table>	Coxal rim.....	} First segment.	Basicostal suture.	Coxa proper.....	
Coxal rim.....	} First segment.					
Basicostal suture.						
Coxa proper.....						
Articulated at the trochacoria between the artes and coixæ.						
Trochanter.....		} Second segment.				
Femasuture.						
Femur.....	<table><tr><td>Proximal region.....</td><td rowspan="3">} Third segment.</td></tr><tr><td>Membranous ring.</td></tr><tr><td>Distal region.....</td></tr></table>		Proximal region.....	} Third segment.	Membranous ring.	Distal region.....
Proximal region.....	} Third segment.					
Membranous ring.						
Distal region.....						
Articulated at the tibiacoria between the artes and coixæ.						
Tibia.....	<table><tr><td>Proximal region.....</td><td rowspan="3">} Fourth segment.</td></tr><tr><td>Membranous ring.</td></tr><tr><td>Distal region.....</td></tr></table>	Proximal region.....	} Fourth segment.	Membranous ring.	Distal region.....	} Fifth segment.
	Proximal region.....	} Fourth segment.				
	Membranous ring.					
Distal region.....						
Articulated at the tarsacoria between the trodia and flexis.						
Five tarsal segments.....		Sixth to tenth segments.				

2. The coxæ are cylindrically elongated. The mesocoxa consists of the eucoxa alone and the meron is reduced. The coxal rim is not provided with special apodemal discs.

3. Both the trochantin and patella are atrophied.

4. The terminal structures of the leg are as follows:

Retained.

Claws.

Calcanea.

Empodium.

Tubercula.

Glenkhöcker.

Atrophied.

Pulvilli.

Planta.

Auxilia.

E. The wings are highly characteristic in form, due mainly to the great reduction of various structures and to the wide modification of the marginal structures.

1. The wings are very narrow and cuneiform, due to the reduction of the alula, squama, and anal lobe.

2. The marginal setæ are extremely developed. They are thought to serve to increase the soaring coefficient of the insect in the air.

3. The well-developed ambient vein is related to the development of the marginal fringe and to the reduction of the true veins.

4. The wings are deciduous along a definite line at the wing basis just distad of the venellæ.

5. The venation is very obscure. The state of development of the veins is shown as follows:

Retained.

Costa and subcosta (coalesced with each other).

Radius (2-branched).

First radial branch.

Radial sector (unbranched).

Media (unbranched?).

First cubitus and second cubitus (coalesced with each other).

Atrophied.

Anal veins.

Secondary veins.

6. The basal sclerites and processes of the wings for the articulation are generally reduced in number and size. The state of their development is shown as follows:

Aliferae.

Retained.

Subalifera (L-shaped and large).

Prealifera (small).

Medalifera (oval and obscure).

Postalifera (oval and large).

Atrophied.

Pleuralifera proper.

Micralifera.

Ental discs.

Pteraliae.

Duritæ.

Retained.

Sigmoidea? (obscure).

Terminalia (small).

Submedia? (obscure).

Atrophied.

Navicula.

Ental discs.

Funditæ.

Atrophied.

Costalla.

Mediella.

Anella.

Pteraliæ—Continued.

Venellæ.

Retained.

Costalis (large).

Radiales (small).

Analis (small).

Alariæ.

Retained.

Medalaria (minute).

Caudalaria? (obscure).

Scutalaria (minute).

Atrophied.

Cephalaria.

Other structures.

Retained.

Tegula (vestigial).

Spiralis (comparatively large).

Ponta (rod-shaped and thickly chitinized).

F. The halteres are normal in structure. The great majority of the basal sclerites and the articular processes are atrophied. The structures retained are the following:

Haltere.

Scabellum (small).

Petiole (elongated).

C+Sc+R (cephalic margin; obscure).

M+Cu+A (caudal margin; obscure).

Capitellum (spoon-shaped).

Basal sclerite.

Tegula (vestigial).

G. The pregenital segments are seven in number, and they are not distinctly differentiated in both sexes, being subequal in shape and structure to each other.

1. The divisions and subdivisions of these segments are as follows:

Pregenital segment.

Tergum (s. lat.).

Tergum (s. str.).

Paratergal groove.

Paratergite.

Tergopleural groove.

Pleurosternum.

2. The abdominal spiracles are all atrophied. The various cuticular structures and their arrangement are shown in text fig. 1.

H. The segmentation of the terminal abdominal region and the relation between it and various appendages and projections are shown in text fig. 5.

1. The constitution and homology of the female genital segments are shown as follows:

Eighth segment.

Tergum.

Antecosta.

Tergum (s. str.).

Paratergite.

One projection.

Two tubercles.

Pleuron.

Appendages.

Stylus (atrophied).

Gonapophysis (first paramere).

Limb base (obscure).

Sternum.

Antecosta.

Thickened area (sternum proper).

Ental ridge (secondary).

Membranous area (ventral wall of the genital chamber).

Ninth segment.

Tergum (fused with that of the postgenital segments).

Pleuron.

Appendages.

Stylus (atrophied).

Gonapophysis (second paramere).

Limb base (atrophied).

Sternum (dorsal wall of the genital chamber).

The genital aperture is found between the eighth and ninth sterna, being guarded by the first parameres.

2. Those of the male genital segments are as follows:

Eighth segment.

Tergum.

Antecosta.

Tergum (s. str.).

Paratergite.

Basal plate (paratergite proper).

Two projections.

Three tubercles.

Pleuron.

Appendages (atrophied).

Limb base (obscure).

Sternum (fused with the pleuron forming the pleurosternum).

Ninth segment.

Tergum (fused with the common terminal tergum).

Pleuron.

Appendages.

Stylus (retained).

Gonapophysis (paramere of the ædeagus).

Limb base (coxite).

Sternum (pons basalis).

Thus, the ædeagus consists of the parameres, median penis, pons basalis, and ejaculatory duct.

3. The postgenital segments are completely fused in both sexes. Their constitution in the female is as follows:

Tenth segment.

Tergum (fused with the common terminal tergum).

Pleuron (obscure).

Sternum (obscure).

Eleventh segment.

Tergum (fused with the common terminal tergum).

Pleuron.

Appendages.

Stylus (prominent cercus).

Gonapophysis (atrophied).

Limb base (cercaria).

Sternum (obscure).

Twelfth segment (periproct).

Tergum (lami supra-analis).

Sternum (lami subanalis).

4. The constitution of the postgenital segments in the male is as follows:

Tenth segment (obscure).

Eleventh segment.

Tergum (obscure).

Pleuron.

Appendages.

Stylus (prominent cercus).

Gonapophysis (atrophied).

Limb base (cercaria).

Sternum (obscure).

Twelfth segment (periproct).

Tergum (lami supra-analis).

Sternum (lami subanalis).

I. The Nymphomyiidæ are considered to be a comparatively low nematocerous family and so specialized as to be quite isolated phylogenetically from all other dipterous groups.

BIBLIOGRAPHY

- AMANS, P. C.
Comparisons des organes du vol dans la série animale. *Ann. Sci. Nat.*
VI 19 (1885) 9-222.
- BERLESS, A.
Gli Insetti, loro organizzazione, sviluppo, abitudini e rapporti coll'uomo.
Soc. Edit. Libreria, Milano (1909).
- BÖVING, A. G.
On the abdominal structure of certain beetle larvae of the campodei-
form type. A study of the relation between the structure of the
integument and the muscles. *Proc. Ent. Soc. Washington* 16 (1914)
55-61.
- CHOLODKOWSKY, N.
Die Embryonalentwicklung von *Phyllodromia* (Blatta) germanica.
Mem. Acad. Sci. St. Petersburg VII 38 (1891) 1-120.
- CHRISTOPHERS, S. R., and P. J. BARRAUD.
The development of the male and female hypopygium of *Phlebotomus*.
Ind. Journ. Med. Res. 13 (1926) 853-870.
- COMSTOCK, J. H.
The Wings of Insects. Ithaca, New York (1918).
An Introduction to Entomology. Ithaca, New York (1924).
- COMSTOCK, J. H., and C. KOCH.
The skeleton of the head of insects. *Am. Nat.* 26 (1902) 13-45.
- COLLINS, C. W.
Dispersion of gipsy-moth larvæ by the wind. *Bull. U. S. Dept. Agr.*
273 (1915) 1-23.
- CRAIGHEAD, F. C.
The determination of the abdominal and thoracic areas of the ceram-
bycid larvae as based on a study of the muscles. *Proc. Ent. Soc.*
Washington 18 (1916) 129-142.
- CRAMPTON, G. C.
A contribution to the comparative morphology of the thoracic scler-
ites of insects. *Proc. Acad. Nat. Sci. Philadelphia* 1909 (1909)
3-54.
The ground plan of a typical thoracic segment in winged insects.
Zool. Anz. 44 (1914) 56-67.
Notes on the thoracic sclerites of winged insects. *Ent. News* 25
(1914) 15-25.
The nature of the veracervix or neck region in insects. *Ann. Ent.*
Soc. Am. 10 (1916) 187-197.
A phylogenetic study of the terminal abdominal segments and ap-
pendages in some female apterygotan and lower pterygotan in-
sects. *Journ. N. Y. Ent. Soc.* 25 (1917) 225-237.
Thoracic sclerites of grasshopper *Dissosteira carolina*. *Ann. Ent.*
Soc. Am. 11 (1918) 320-347.

CRAMPTON, G. C.—Continued.

- A phylogenetic study of the terminal abdominal structures and genitalia of male Apterygota, ephemeroidea, Odonata, Plecoptera, Neuroptera, Orthoptera, and their allies. *Bull. Brooklyn Ent. Soc.* 13 (1918) 49-68.
- The genitalia and terminal abdominal structures of male Neuroptera and Mecoptera with notes on the Psocidae, Diptera, and Trichoptera. *Psyche* 25 (1918) 47-59.
- Notes on the ancestry of Diptera, Hemiptera, and other insects related to Neuroptera. *Trans. Ent. Soc. London* 1919 (1919) 93-118.
- A phylogenetic study of the mesothoracic terga and wing bases in Hymenoptera, Neuroptera, Mecoptera, Diptera, Trichoptera, and Lepidoptera. *Psyche* 26 (1919) 58-64.
- A comparison of the external anatomy of the lower Lepidoptera and Trichoptera. *Psyche* 27 (1920) 23-44.
- A comparison of the genitalia of male Hymenoptera, Mecoptera, Neuroptera, Diptera, Trichoptera, Lepidoptera, Homoptera, and Sterpsi-
ptera, with those of lower insects. *Psyche* 27 (1920) 34-45.
- Remarks on the basic plan of the terminal abdominal structures of the males of winged insects. *Canad. Ent.* 52 (1920) 178-183.
- A comparison of the terminal abdominal structures of insects and Crustacea. *Ent. News* 32 (1921) 257-264.
- The sclerites of the head, and the mouth-parts of certain immature and adult insects. *Ann. Ent. Soc. Am.* 14 (1921) 65-100.
- The phylogeny and classification of insects. *Journ. Ent. Zool.* 16 (1924) 33-47.
- Remarks on the phylogeny and interrelationships of nematocerous Diptera. *Psyche* 31 (1924) 238-242.
- A phylogenetic study of the thoracic sclerites of the non-tipuloid nematocerous Diptera. *Ann. Ent. Soc. Am.* 18 (1925) 49-67.
- A phylogenetic study of the thoracic sclerites of the psychodoid Diptera, with remarks on the interrelationships of the Nematocera. *Ent. News* 37 (1926) 33-39 and 65-70.
- A comparison of the neck and prothoracic sclerites throughout the orders of insects from the standpoint of phylogeny. *Trans. Am. Ent. Soc.* 52 (1926) 199-248.
- The thoracic sclerites and wing bases of the roach, *Periplaneta americana*, and the basal structures of the wings of insects. *Psyche* 24 (1927) 59-72.
- The evolution of insects, chilopods, diplopods, Crustacea, and other arthropods indicated by a study of the head capsule. *Canad. Ent.* 60 (1928) 129-141.
- CRAMPTON, G. C., and W. H. HASEY.
The basal sclerites of the leg in insects. *Zool. Jahrb. Anat.* 39 (1915) 1-26.

DIRKES, L.

Das larvale Muskelsystem und die Entwicklung der imaginalen Flugmuskulatur von *Psychoda alternata* Say. Zeit. Morphol. Ökol. Tiere 11 (1928) 182-228.

EDWARDS, F. W.

The nomenclature of the parts of male hypopygium of Diptera Nematocera, with special reference to mosquitoes. Ann. Trop. Med. Paras. 14 (1920) 23-40.

Deuterophlebia mirabilis, gen. et sp. nov., a remarkable dipterous insect from Kashmir. Ann. & Mag. Nat. Hist. 9 (1922) 379-387.

HAMMOND, A.

Thorax of the blow-fly. Journ. Linn. Soc. London 15 (1881) 9-31.

HANDLIRSCH, A.

Die fossilen Insekten und die Phylogenie der rezenten Formen. Leipzig (1908).

HEBERDY, R. E.

Zur Entwicklungsgeschichte, vergleichenden Anatomie und Physiologie der weiblichen Geschlechtsausführwege der Insekten. Zeit. Morphol. Ökol. Tiere 22 (1931) 416-586.

HESSE, R.

Untersuchungen über die Organe der Lichtempfindung bei niederen Thieren. VII. Von den arthropoden Augen. Zeit. wiss. Zool. 70 (1901) 347-473.

HEYMONS, R.

Die Segmentierung des Insektenkörpers. Abhandl. Akad. Wiss. Berlin 1895 (1895) 1-39.

Zur Morphologie der Abdominalanhänge bei den Insekten. Morphol. Jahrb. 24 (1896) 178-204.

Über die abdominalen Körperanhänge der Insekten. Biol. Centralb. 16 (1896) 854-864.

Entwicklungsgeschichtliche Untersuchungen an *Lepisma saccharima* L. Zeit. Wiss. Zool. 62 (1897) 583-631.

Der morphologische Bau des Insektenabdomens. Zool. Centralb. 6 (1899) 537-556.

Die Hinterleibsanhänge der Libellen und ihrer Larven. Ann. K. Naturhist. Hofmuseums. Wien 19 (1904) 21-58.

HOPKINS, A. D.

The genus *Dendroctonus*. U. S. Dept. Agr. Bur. Ent. Tech. Ser. No. 17 (1909) 1-164.

IMMS, A. D.

A General Textbook of Entomology. London (1925).

KELLOGG, V. L.

The mouth-parts of the nematoceros Diptera. Psyche 8 (1899) 303-306, 327-330, 346-348, 355-359, 363-365.

KEMPER, H.

Morphogenetische Untersuchung über das Tracheensystem von *Psychoda phalaenoides* (Diptera). Dissertation, Münster (1925).

MACGILLIVRAY, A. D.

External Insect-anatomy. Urbana, Illinois (1923).

MATHESON, R.

The mosquitoes of North America. Springfield, Illinois (1929).

MIYAKE, T.

Studies on the fruit-flies of Japan. I. Japanese orange-fly. Bull. Imp. Cent. Agr. Exp. Stat. 2 (1919) 87-160.

NELSON, J. A.

The Embryology of the Honey-Bee. Princeton Univ. (1915).

Morphology of the honey-bee larva. Journ. Agr. Res. 28 (1924) 1167-1213.

NEWELL, A. G.

The comparative morphology of the genitalia of insects. Ann. Ent. Soc. Am. 11 (1918) 109-142.

PETERSON, A.

The head-capsule and mouth-parts of Diptera. Ill. Biol. Monog. 3 (1916) 1-62.

PROCHNOW, O.

Mechanik des Insektenfluges. Handb. Ent. (Schröder) 1 (1924) 534-569.

SAMTLEBEN, B.

Anatomie und Histologie der Abdominal- und Thorax-muskulatur von Stechmückenlarven. Zeit. wiss. Zoöl. 134 (1929) 180-269.

SAUNDERS, L. B.

Some marine insects of the Pacific coast of Canada. Ann. Ent. Soc. Am. 21 (1928) 521-545.

SNODGRASS, R. E.

The terminal abdominal segments of female Tipulidæ. Journ. N. Y. Ent. Soc. 11 (1903) 177-183.

The thorax of insects and the articulation of the wing. Proc. U. S. Nat. Mus. 38 (1909) 511-595.

Anatomy and metamorphosis of apple maggot, *Rhagoletis pomonella* Walsh. Journ. Agr. Res. 28 (1924) 1-36.

Morphology and mechanism of the insect thorax. Smith. Misc. Coll. 80 (1927) 1-108.

Morphology and evolution of the insect head and its appendages. Smiths. Misc. Coll. 81 (1928) 1-158.

The thoracic mechanism of a grasshopper, and its appendages. Smiths. Misc. Coll. 82 (1929) 1-109.

Morphology of the insect abdomen. Part I. General structure of the abdomen and its appendages. Smiths. Misc. Coll. 85 (1931) 1-123.

TILLYARD, R. J.

The Insects of Australia and New Zealand. Sydney (1926).

TOKUNAGA, M.

The morphological and biological studies on a new marine crane fly, *Limonia* (*Dicranomyia*) *monostromia*, from Japan. Mem. Coll. Agr. Kyoto Imp. Univ. No. 10 (1930) 1-93.

Morphological and biological studies on a new marine chironomid fly, *Pontomyia pacifica*, from Japan. Part I. Mem. Coll. Agr. Kyoto Imp. Univ. No. 19 (1932) 1-56.

A remarkable dipterous insect from Japan, *Nymphomyia alba* gen. et sp. nov. Ann. Zoöl. Jap. 13 (1932) 559-569.

A phylogenetic study of the thoracic sclerites of the Deuterophlebiidae. Rep. Jap. Ass. Adv. Sci. 8 (1932) 428-434.

WALKER, E. M.

The terminal structures of orthopteroid insects: a phylogenetic study, Part II. Ann. Ent. Soc. Am. 15 (1922) 1-76.

WEBER, H.

Lehrbuch der Entomologie. Jena (1933).

WEINLAND, E.

Über die Schwinger (Halteren) der Dipteren. Zeit. wiss. Zoöl. 51 (1890) 55-166.

WHEELER, W. M.

The embryology of *Blatta germanica* and *Doryphora decimlineata*. Journ. Morphol. 3 (1889) 291-386.

A contribution to insect embryology. Journ. Morphol. 8 (1893) 1-160.

YOUNG, B. P.

Attachment of the abdomen to the thorax in Diptera. Mem. Cornell Univ. Agr. Exp. Stat. Mem. 44 (1921) 255-306.

YUASA, H.

The anatomy of the head and mouth-parts of Orthoptera and Euplexoptera. Journ. Morphol. 33 (1920) 251-307.

ILLUSTRATIONS

NYMPHOMYIA ALBA TOKUNAGA

PLATE 1. HEAD AND ANTENNA

FIG. 1. Lateral aspect of head.

2. Dorsal aspect of head.

3. Ventral aspect of head.

4. Dorsal aspect of dextral antenna.

ac, Antacoria.

bx, Basipharynx.

ce, Compound eye.

es, Epicranial stem.

fl, Segment of flagellum.

is, Intersegmental sensilla.

la, Papilliform projection
(labium?).

lp, Labiumlike projection.

mc, Mouth cavity.

o, Occipital margin.

oc, Ocellus.

of, Occipital foramen.

ol, Oculata.

op, Oesophageal pump.

p, Pedicel.

sn, Snoutlike projection.

sp, Scape.

t, Toothlike projection.

vr, Visorlike projection.

vt, Vertex.

PLATE 2. THORAX

FIG. 5. Lateral aspect.

6. Dorsal aspect.

7. Ventral aspect.

ad, Abdominal segment.

an, Antepnotum.

bs, Basisternum.

c, Coxafossa.

cc, Cervix or cervacoria.

co, Coxacoila.

em, Epimeron.

en, Ental invagination or
caudal phragma.

et, Episternum.

h, Haltere.

la, Lateral phragma of
scutellum.

m, Mesascutella.

ma, Medalaria.

mc, Mesocoria.

md, Middorsal suture.

ms, Midventral suture.

n, Notepimeron.

p, Pleural suture.

pa, Paraphragma.

pc, Parascutulis.

pl, Postscutellum.

pn, Postpronotum.

pp, Propleuron.

prs, Presternum.

ps, Parascutella.

pst, Prosternum.

pt, Parasternite.

pv, Pseudosutural fovea.

r, Rotaxis.

s, Scutalaria.

sa, Supra-alar seta.

sc, Sternacoila.

se, Sternepimeron.

si, Scutulis.

sl, Spiralis.

sm, Sternellum.

sps, Scutopræscutum.

ss, Secondary (transsternal) suture.

st, Transversal stripe.

su, Scutellum.

ws, Wing base.

PLATE 3. LEGS AND HALTERE

FIG. 8. Foreleg.

9. Middle leg.

10. Hind leg.

- | | |
|--|----------------------------------|
| <i>c</i> , Claw. | <i>p</i> , Proximal subdivision. |
| <i>cn</i> , Calcanea. | <i>sn</i> , Sensilla. |
| <i>cx</i> , Coxa. | <i>t</i> , Trochanter. |
| <i>d</i> , Distal subdivision. | <i>ta</i> , Trochantis. |
| <i>e</i> , Empodium. | <i>tb</i> , Tibia. |
| <i>f</i> , Femur. | <i>tba</i> , Tibiartis. |
| <i>fs</i> , Femasuture. | <i>tbc</i> , Tibiacoila. |
| <i>gh</i> , Glenkhöcker. | <i>tc</i> , Trochacoila. |
| <i>mc</i> , Basicostal suture of coxa. | <i>to</i> , Trochacoria. |
| <i>mf</i> , Membranous ring of femur. | <i>tp</i> , Tarsal spine. |
| <i>mt</i> , Membranous ring of tibia. | <i>ts</i> , Tarsal segment. |
| | <i>tu</i> , Tubercula. |

11. Sinistral haltere, lateral aspect.

- | | |
|--|--|
| <i>bsr</i> , Basal swelling of ro-taxis. | <i>ps</i> , Parascutella. |
| <i>ca</i> , Capitellum. | <i>ptl</i> , Petiole. |
| <i>em</i> , Epimeron. | <i>r</i> , Rotaxis. |
| <i>et</i> , Episternum. | <i>sad</i> , Sternal side of abdomen. |
| <i>in</i> , Invagination between thorax and abdomen. | <i>sc</i> , Scabellum. |
| <i>m</i> , Mesascutella. | <i>sp</i> , Porelike puncture (spiracle?). |
| | <i>tad</i> , Tergal side of abdomen. |
| | <i>te</i> , Tegula. |

PLATE 4. WING AND TERMINAL SEGMENTS OF FEMALE

FIG. 12. Wing.

- | | |
|----------------------------|-------------------------------|
| <i>am</i> , Anal margin. | <i>om</i> , Outer margin. |
| <i>av</i> , Ambient vein. | <i>ps</i> , Placoid sensilla. |
| <i>C</i> , Costa. | <i>R</i> , Radius. |
| <i>cm</i> , Costal margin. | <i>Rs</i> , Radial sector. |
| <i>Cu</i> , Cubitus. | <i>Sc</i> , Subcosta. |
| <i>M</i> , Media. | |

13. Wing base, ventrolateral aspect.

- | | |
|--|--|
| <i>as</i> , Analis. | <i>ps</i> , Parascutella. |
| <i>cs</i> , Costalis. | <i>r</i> , Rotaxis. |
| <i>ma</i> , Medalaria. | <i>ra</i> , Radialis. |
| <i>ml</i> , Medalifera. | <i>sa</i> , Supra-alar seta. |
| <i>n</i> , Notepimeron. | <i>se</i> , Sternepimeron. |
| <i>np</i> , Notepisternum. | <i>sl</i> , Spiralis. |
| <i>p</i> , Pleural suture. | <i>sp</i> , Porelike puncture (spiracle?). |
| <i>pal</i> , Prealifera. | <i>su</i> , Scutellum. |
| <i>po</i> , Ponta. | <i>t</i> , Terminalia. |
| <i>pol</i> , Postalifera. | <i>te</i> , Tegula. |
| <i>pr</i> , Subalifera (pleuralifera). | <i>ws</i> , Wing base. |

14. Terminal segments of female, dorsal aspect.
15. Terminal segments of female, lateral aspect.
16. Terminal segments of female, ventral aspect.

<i>a</i> , Anus.	<i>ot</i> , Octatergum.
<i>at</i> , Antecosta.	<i>pj</i> , Paratergal projection.
<i>cc</i> , Cercaria.	<i>pp</i> , Paraproct.
<i>ce</i> , Cercus.	<i>pt</i> , Paratergite.
<i>ec</i> , Ental thickening.	<i>sa</i> , Lami subanalis.
<i>ep</i> , Epiproct.	<i>sc</i> , Segmacoria.
<i>gc</i> , Genital chamber.	<i>su</i> , Lami supra-analis.
<i>os</i> , Octasternum.	<i>t</i> , Tubercle.

PLATE 5. TERMINAL SEGMENTS OF MALE

FIG. 17. Lateral aspect.

18. Dorsal aspect.

19. Ventral aspect.

<i>a</i> , Anus.	<i>pa</i> , Paramere.
<i>aa</i> , Aedeagus.	<i>pb</i> , Ponta basalis.
<i>at</i> , Antecosta.	<i>pj</i> , Paratergal projection.
<i>cc</i> , Cercaria.	<i>pp</i> , Paraproct.
<i>ce</i> , Cercus.	<i>pt</i> , Paratergite.
<i>cx</i> , Coxite.	<i>s</i> , Style.
<i>h</i> , Harpe.	<i>sa</i> , Lami subanalis.
<i>if</i> , Intersegmental fur- row.	<i>sc</i> , Segmacoria.
<i>os</i> , Octasternum.	<i>su</i> , Lami supra-analis.
<i>ot</i> , Octatergum.	<i>t</i> , Tubercle.
<i>p</i> , Penis.	<i>te</i> , Telson.

TEXT FIGURES

FIG. 1. Head of *Nymphomyia alba* Tokunaga. Cross sections of the basipharynx; *a*, through the attachments of the anterior dilators; *b*, through those of the posterior dilators; and, *c*, of the posterior region before the oesophagus.

<i>bx</i> , Basipharynx.	<i>sbg</i> , Suboesophageal ganglion.
<i>cn</i> , Connective nerve.	<i>sd</i> , Salivary duct.
<i>fg</i> , Frontal ganglion.	<i>sg</i> , Salivary gland.
<i>oe</i> , Oesophagus.	<i>slp</i> , Salivary pump.
<i>ol</i> , Oculata.	<i>sp</i> , Scape.
<i>op</i> , Oesophageal pump.	<i>spg</i> , Supraoesophageal ganglion.
<i>p</i> , Pedicel.	

2. Diagrammatic arrangement of the cuticular structures of the abdominal segment.

<i>ac</i> , Antecosta.	<i>tp</i> , Transparent pattern.
<i>lt</i> , Lateral tubercle.	<i>X-X</i> , Tergoparatergal line.
<i>tb</i> , Tubercle.	<i>Y-Y</i> , Tergopleural line.

3. Hypothetical definitive sternum. (Modified from Snodgrass, 1931.)

<i>acx</i> , Precoxal bridge.	<i>sa</i> , Sternartis.
<i>Bs</i> , Basisternum.	<i>sc</i> , Sternacolla.
<i>cx</i> , Coxa.	<i>Sl</i> , Sternellum.
<i>fs</i> , Furcal suture.	<i>spn</i> , Spinafurca.
<i>Ls</i> , Laterosternite.	<i>sps</i> , Secondary presternal suture.
<i>pcx</i> , Postcoxal bridge.	<i>Ss</i> , Spinasternum.
<i>Ps</i> , Presternum.	

4. Hypothetical venation.

<i>Sc</i> , Subcosta.	<i>M</i> , Media.
<i>R₁</i> , First branch of radius.	<i>Cu</i> , Cubitus.
<i>Rs</i> , Radial sector.	

5. Diagram of the theoretical abdominal segment. (Modified from Snodgrass, 1931.)

<i>as</i> , Antecostal suture.	<i>S</i> , Sternum.
<i>gs</i> , Gonapophysis.	<i>s</i> , Spiracle.
<i>lm</i> , Limb base or pleuron.	<i>sy</i> , Stylus.
	<i>T</i> , Tergum.
<i>p</i> , Precosta.	<i>x-x</i> , Tergopleural line.
<i>pa</i> , Paratergite.	

6. Diagrams illustrating the concept of the structural plan of the terminal abdominal segments adopted in this paper, 1, dorsal aspect, male; 2, ventral aspect, male; 3, ventral aspect of the post-genital segments, male; 4, dorsal aspect, female; 5, ventral aspect, female.

<i>a</i> , Anus.	<i>pn</i> , Pleuron.
<i>aa</i> , Ædeagus.	<i>pt</i> , Paratergite.
<i>at</i> , Antecosta.	<i>S</i> , Sternum.
<i>ep</i> , Epiproct.	<i>s</i> , Stylus, or cercus.
<i>ga</i> , Genital aperture.	<i>sa</i> , Lami subanalis.
<i>gs</i> , Gonapophysis, or paramere.	<i>sc</i> , Segmacoria.
	<i>su</i> , Lami supra-analis.
<i>lm</i> , Limb base, coxite, or cercaria.	<i>T</i> , Tergum.
<i>pb</i> , Pons basalis.	<i>vaa</i> , Ventral wall of genital chamber.
<i>pl</i> , Periproct.	

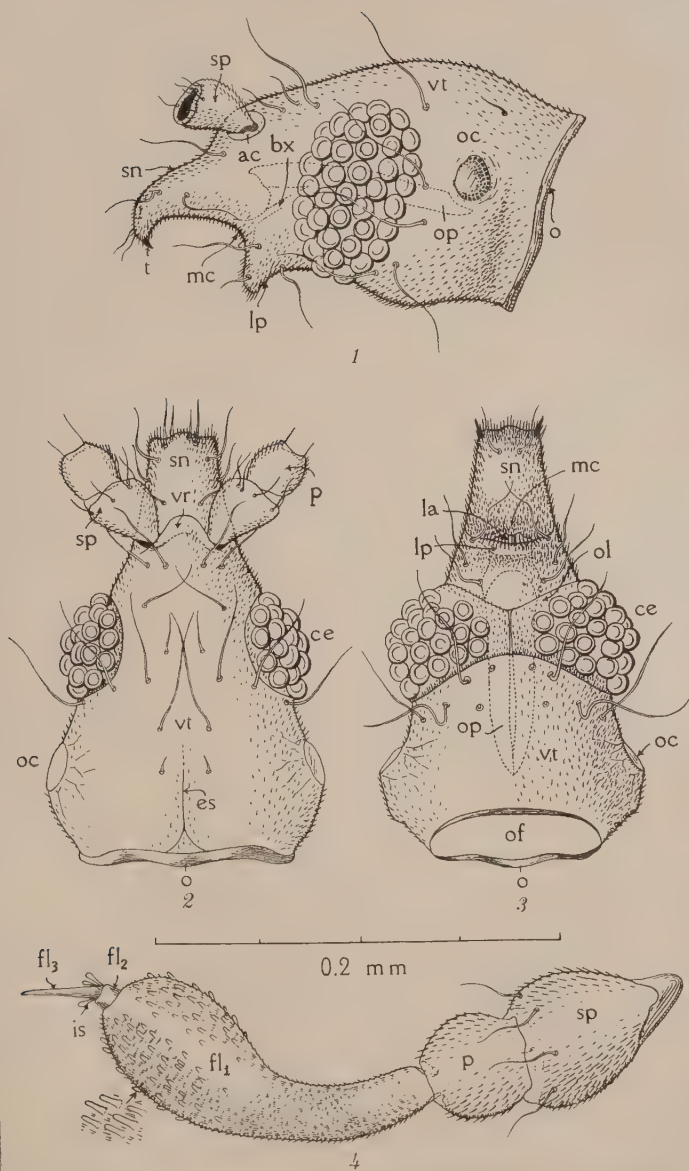


PLATE 1.

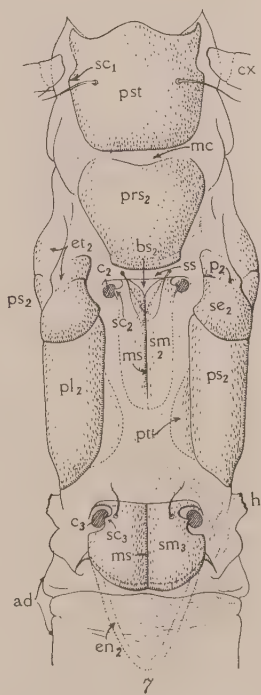
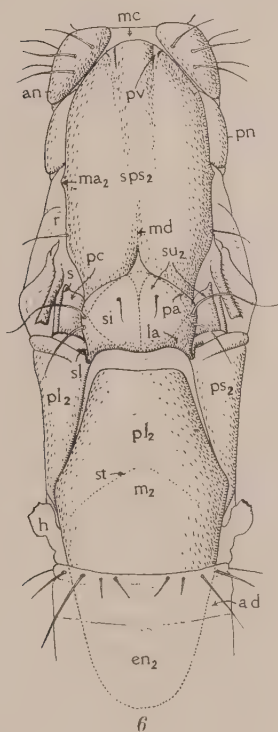
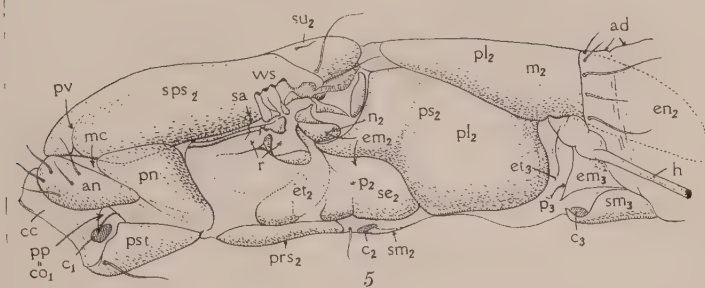


PLATE 2.

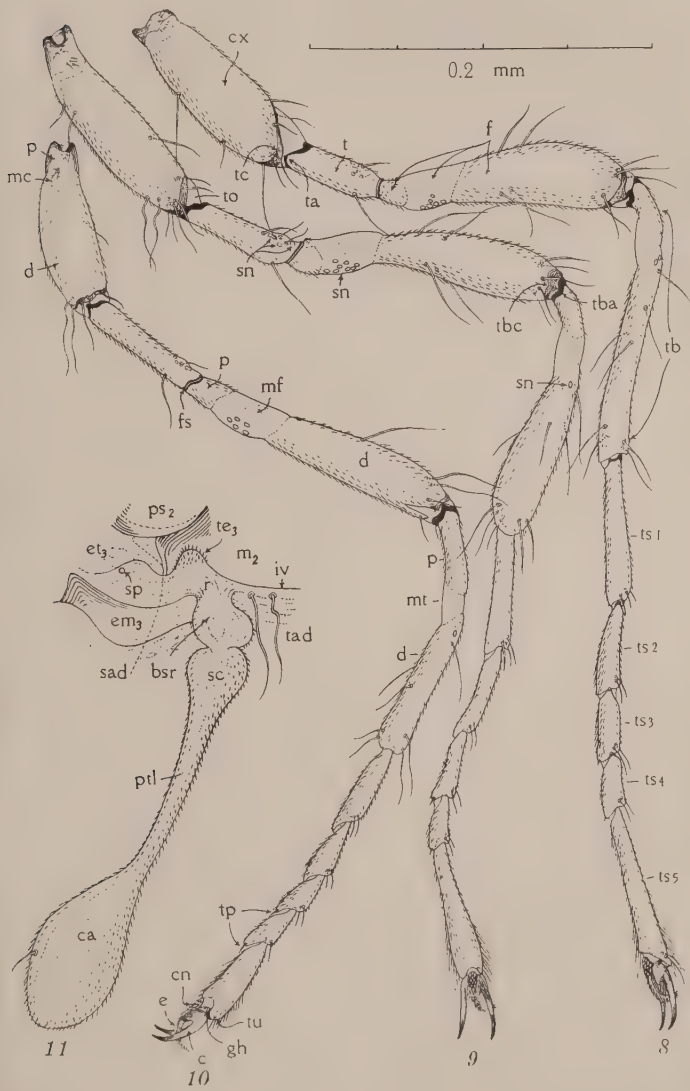
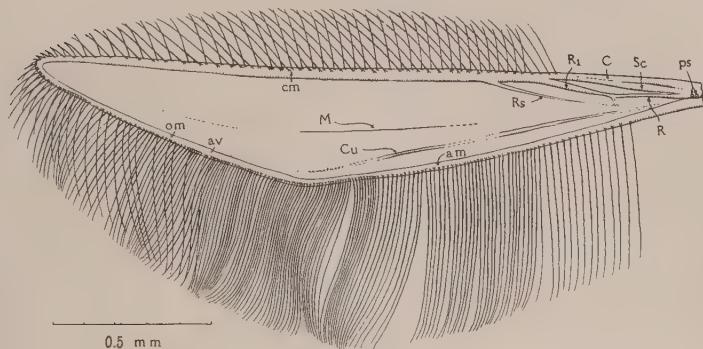
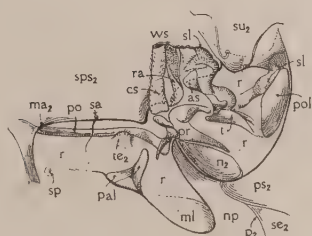


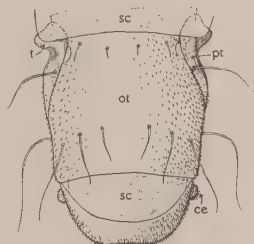
PLATE 3.



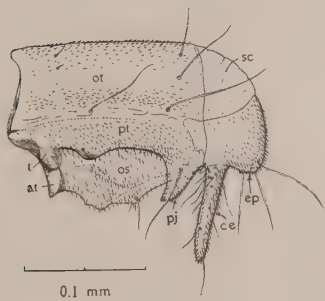
12



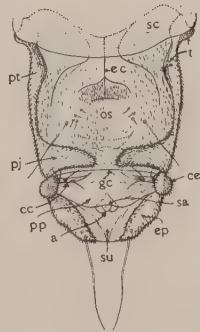
13



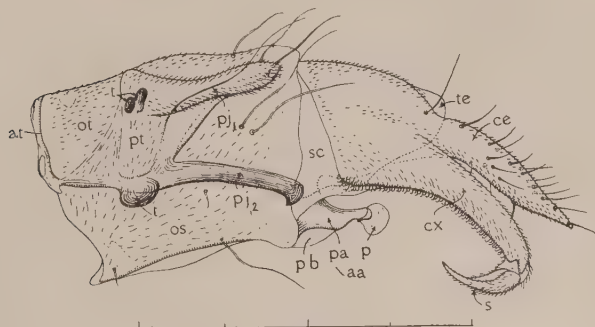
14



15

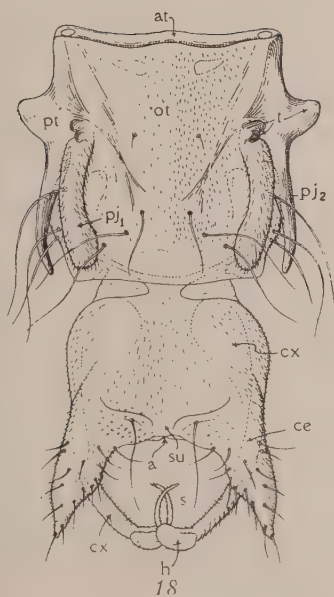


16

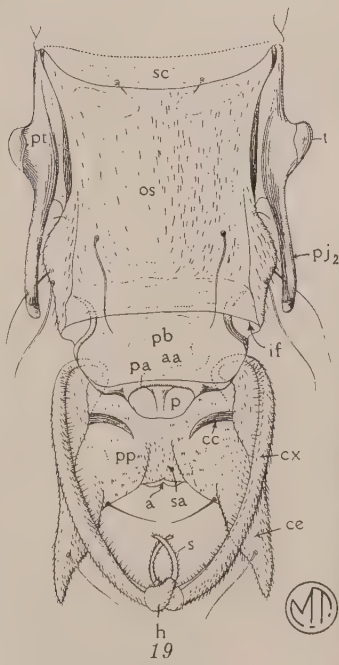


0.2 mm

17



18



19

PHILIPPINE PARAPERCIDÆ

By CLARO MARTIN and HERACLIO R. MONTALBAN

Of the Fish and Game Administration, Bureau of Science, Manila

THREE PLATES

The present paper contains a review of the species of the family Parapercidæ known to inhabit Philippine waters. It is based on specimens in the collection of the Fish and Game Administration, Bureau of Science.

PARAPERCIDÆ

Body elongate, subcylindrical, posteriorly compressed, covered with small ctenoid scales; head a little depressed; eyes more or less lateral, close together; mouth moderate or denticulate; interopercle usually not entire; opercle with a spine; subopercle either blunt or pointed; gill membranes united, free from isthmus; branchiostegals 6; pseudobranchiæ present; dorsal fin long, usually continuous; anal similar to soft dorsal; ventrals thoracic, I-5; air bladder absent; pyloric cæca few.

Small fishes found in reefs and along shores, sometimes in deeper waters, from the Red Sea and the east coast of Africa through the seas of India to Polynesia.

According to the scheme of classification of Jordan the Parapercidæ are closely related to the Mugiloididæ on one side and to the Pteropsaridæ on the other. Species of these two families have so far been neither collected nor reported from the Philippines.

Genus PARAPERCIS Bleeker

Parapercis BLEEKER, Ned. Tijdschr. Dierk. 1 (1863) 236.

Body cylindrical, rather elongate; cleft of mouth oblique; teeth in villiform bands with small curved canines; no teeth on palatines; teeth on vomer; dorsal divided, spinous portion with four or five spines.

Key to the Philippine species of Parapercis Bleeker.

*a*¹. Spinous dorsal with five spines.

*b*¹. Caudal with black dots; no caudal blotch.

- c¹. Suprascapular region without a blotch.
Parapercis cylindrica (Bloch).
 c². Suprascapular region with a white-and-black-ringed brown spot.
Parapercis tetracantha (Lacépède).
 b². Caudal blotch present.
 c¹. Blotch on caudal large, black; sides of body with three to seven ocelli..... *Parapercis hexophthalma* (Cuvier and Valenciennes).
 c². Blotch on caudal white; cheeks with oblique, narrow bands.
Parapercis dorsonebulosa sp. nov.
 a². Spinous dorsal with four spines.
 b¹. Suprascapular region with a white-edged ocellus, head with black dots *Parapercis clathrata* Ogilby.
 b². Suprascapular region not ocellated; head with brown blotches.
Parapercis montillai sp. nov.

PARAPERCIS CYLINDRICA (Bloch). Plate 1, fig. 1.

Sciæna cylindrica BLOCH, Ausl. Fische 6 (1792) 42, pl. 299, fig. 1.

Percis cylindrica CUVIER and VALENCIENNES, Hist. Nat. Poiss. 4°. 3 (1829) 199; BLEEKER, Nat. Tijdschr. Ned. Ind. 2 (1863) 235; GÜNTHER, Cat. Brit. Mus. 2 (1860) 239.

Parapercis cylindrica JORDAN and RICHARDSON, Bull. Bur. Fisheries 27 [(1907) 1908] 281; WEBER, Siboga Exp., Fische (1913) 519; FOWLER, Mem. P. Bishop Mus. 10 (1928) 424.

Dorsal V, 21; anal 18 or 19; scales on lateral line 49 or 50; between lateral line and origin of dorsal 4; between lateral line and origin of anal 17 or 18.

Body elongate, moderately compressed, its depth 4 to 4.6 in length; depth of caudal peduncle 2.5 to 3 in head; dorsal profile almost as strongly arched as ventral outline, but a little more curved; head small, pointed, 3.4 to 3.7 in length; snout acutely rounded at tip, 2.5 to 3.3 in head; eye small, moderately high, almost equidistant from tip and edge of opercle, 3.4 to 3.9; interorbital flat, wide, 8.8 to 11.4; mouth small, oblique; lips not broad; premaxillaries not very protractile; maxillary almost entirely concealed by preorbital, extending to, or a little behind, anterior border of eye; upper jaw with an outer series of enlarged teeth which are coarser in front, with one short curved canine on each side and a band of villiform teeth inside; lower jaw with an outer series of coarse teeth in front, with a long canine on each side at the termination of the series, and an inner villiform band in front, continuing posteriorly to a single series of enlarged ones; villiform teeth on vomer. A spine at upper angle of opercle; interopercle and subopercle terminate in a spine; that of former sometimes blunt.

A rather deep notch between the spinous and soft dorsals; third and fourth spines longest, as long as snout; or slightly

longer; anterior dorsal rays as long as distance from tip of snout to hind margin of pupil; anal inserted below fifth dorsal ray; pectoral small, rounded, 4.5 to 4.9; ventral slender, reaching as far as sixth anal ray, 3.1 to 3.7; caudal rounded or slightly so, with upper lobe pointed but very slightly produced.

Ground color in alcohol grayish white to yellowish, nine brownish to blackish vertical bands on each side of body, the middle ones spindle-shaped; a short dark-edged band on snout from its tip to eye where it joins another one crossing middle of eye longitudinally or slightly obliquely; top of head with a coarse network of very pale blue, inclosing brownish spaces; a vertical brown band from lower part of eye across cheek; a narrower band of same color running obliquely across jugular region, meeting its kind ventrally; a blackish blotch with a narrow strip of white above at basal half of spinous dorsal; pectoral and ventral, respectively, yellowish brown and brownish gray in life; soft dorsal with yellow edge and basal black spots; dusky areas at anterior portion gradually become defined as small spots posteriorly; anal with many small dusky spots sometimes fused to form vertical bands; caudal brownish in life, spotted with dark blackish brown, larger at base, with white edge and with a submarginal dusky border.

This species is seemingly the commonest of the family. It is represented in the collection by specimens ranging in length from 48.5 to 135 millimeters collected from different localities from Polillo southward to Sitankai.

PARAPERCIS TETRACANTHA (Lacépède). Plate 1, fig. 2.

Labrus tetracanthus LACÉPÈDE, Hist. Nat. Poiss. 4°. 3 (1802) 428, 473, [not *Percis tetracanthus* BLEEKER, Nat. Tijdschr. Ned. Ind. 4 (1853) 458, which is *P. quadrispinosus* (Weber)].

Percis cancellata CUVIER and VALENCIENNES, Hist. Nat. Poiss. 4°. 3 (1829) 200; BLEEKER, Nat. Tijdschr. Ned. Ind. 9 (1855) 501; GÜNTHER, Cat. Brit. Mus. 2 (1860) 240.

Parapercis tetracanthus JORDAN and RICHARDSON, Bull. U. S. Bur. Fish. 27 [(1907) 1908] 281; WEBER, Siboga Exp., Fische 65 (1913) 518.

Parapercis tetracantha OGILBY, Proc. Roy. Soc. Queensl. 23 (1910) 40. Not described.

Dorsal V, 21; anal 18; scales on lateral line 59 to 60; between lateral line and origin of dorsal 8; between lateral line and origin of anal 19 to 22.

Body elongate, rather cylindrical, its depth 5.9 to 6.2 in length; caudal peduncle compressed, its depth 3 to 3.3 in length of head;

dorsal outline of head and body slightly more arched than ventral; head rather depressed with moderately bulging cheeks, 3.3 to 3.5 in length, snout regular, 2.8 to 3 in head; eye large, much advanced forward, its upper margin slightly projecting above head, 4.6 to 4.9; interorbital narrow, 9.2 to 11; mouth moderately large, oblique; lips broad; lower jaw projecting; premaxillaries protractile; posterior portion of maxillary partly exposed, extending a little beyond anterior border of eye; upper jaw with an outer series of coarse teeth with several long ones in front and on the sides, and an inner villiform band narrowing posteriorly; lower jaw with an outer series of coarse enlarged teeth, four in front and three at each side directed posteriorly, and an inner villiform band not continuous behind; teeth also on vomer; preopercle entire; a strong, rather flat spine on upper angle of opercle.

Membrane uniting spinous and soft dorsals low; third and fourth spine longest, as long as eye or about equal to it; anterior dorsal rays as long as distance from snout to about middle of pupil and inserted below fifth dorsal ray; pectoral short, broadly rounded, its length 5.4 to 5.7 in body; ventral pointed, 4.4 to 5.2; caudal rounded, with projecting upper and lower lobes, the former a little longer than the latter, its length 5.2 to 5.7.

Scales behind occiput, on cheeks, breast, and abdomen smooth; finely ctenoid all over the rest of body and base and upper and lower lobes of caudal; snout, sides of head, and occiput naked.

Color in alcohol dark brown, lighter below on each side; three series of light blotches with slightly darker centers; eight blotches along each side of back, comprising the first series, each continuous with the corresponding blotch on the other side; second series along middle of body consists of nine alternating with those above, the third corresponding with the second, each with white edge, narrow above and wider below across the belly, and continuing with that of the other side; a black dot on each side of tip of snout; a long blackish blotch on each side of upper lip; lower lip and chin brown; a broad brown blotch on cheeks below eyes; a large white-and-black-ringed brown spot on suprascapular region; a black vertical blotch below base of pectoral; two pairs of small black blotches on belly, sometimes connected; a larger black blotch below base of pectoral; membranous portion of first dorsal whitish with some shades of brownish; soft dorsal transparent with three series of black

spots, those at base fewer and larger; anal with whitish edge and dusky submarginal border; caudal with a number of dusky spots with black centers; base of upper lobe of caudal with small dusky brown blotch.

Here described from four specimens, 170 to 200 millimeters long, from the following localities: MINDORO, Mindoro Province, Calapan. ROMBLON, Romblon Province, Romblon. MINDANAO, Cotabato Province, south coast.

PARAPERCIS HEXOPHTHALMA (Cuvier and Valenciennes). Plate 2, fig. 1.

Percis cylindrica RÜPPELL, Atl. Reise Nörd. Afrika, Fische (1828) 18, pl. 5, fig. 2 (not *Sciæna cylindrica* Bloch, which is *P. cylindrica* Cuvier and Valenciennes).

Percis hexophtthalma CUVIER and VALENCIENNES, Hist. Nat. Poiss. 4°. 3 (1829) 202; GÜNTHER, Cat. Brit. Mus. 2 (1860) 239; PLAYFAIR and GÜNTHER, Fish. Zanzibar (1866) 68; DAY, Fishes of India 4° (1878) 263.

Percis polyophtthalma CUVIER and VALENCIENNES, Hist. Nat. Poiss. 4°. 3 (1829) 203; PLAYFAIR and GÜNTHER, Fish. Zanzibar (1866) 68; KLUNZINGER, Fisch. Roth. Meer. 1 (1870) 816.

Percis caudimaculata RÜPPELL, Neue Wirbelthiere, Fische (1835-1840) 98; BLEEKER, Verh. Bat. Gen. 22 (1849) 54.

Parapercis hexophtthalma JORDAN and SNYDER, Proc. U. S. Nat. Mus. 24 (1902) 466; EVERMANN and SEALE, Bull. U. S. Bur. Fish. 26 (1906) 103; WEBER, Siboga Exp., Fische 65 (1913) 518; BARNARD, Ann. So. African Mus. 21 (1925-27) 422, pl. 19, fig. 1; FOWLER, Mem. Bernice P. Bishop Mus. 10 (1928) 424.

? *Parapercis tetracanthus* JORDAN and RICHARDSON, Bull. U. S. Bur. Fish. 27 (1908) 281.

Dorsal V, 21; anal 18; scales on lateral line 60 to 61; between lateral line and origin of dorsal 8, between lateral line and origin of anal 19 to 23.

Body elongate, subcylindrical, its depth 5.3 to 5.6 in length; depth of compressed caudal peduncle 2.8 to 3 in head; dorsal outline at head region more arched than ventral; head pointed, 3.4 to 3.5 in length; snout quite long, 2.5 to 2.7 in head; eye large, nearer tip of snout than edge of opercle, located high, the upper margin projecting above outline of head, 4.2 to 4.6; interorbital narrow, 8.4 to 11; mouth moderate, oblique, lips broad; jaws not quite equal; premaxillaries protractile; maxillary concealed by preorbital, reaching a little beyond anterior border of eye; upper jaw with an outer series of conical teeth, with nine or ten in front enlarged, curved and caninelike, and with an inner wide band of small ones narrowing posteriorly; lower jaw with eight teeth in front and three enlarged teeth at

middle of outer series, and an inner big patch of small ones; a small patch of fine teeth on the vomer; preopercle entire with a strong rather flat spine at posterior angle.

Membrane connecting spinous and soft dorsals high; third and fourth spine about equal, almost as long as eye diameter or slightly longer; rays much higher than spines, anterior ones equal to distance from snout to pupil; anal inserted below fifth dorsal ray; pectoral rounded, 4.7 to 4.9 in body length; ventrals pointed, 4 to 4.5; caudal rounded with upper pointed lobe slightly projecting.

Scales behind occiput, on cheeks, and on breast smooth; on the rest of body and on caudal fin finely ctenoid; snout, inter-orbital space, and occiput naked.

Color in alcohol yellowish to grayish brown with irregularly scattered blackish spots above, whitish below; round blackish dots all over head; on sides seven to eight white, somewhat rectangular, spaces with one or several blackish spots inside, and a row of blackish spots below; three to seven black ocelli, each surrounded by a narrow white ring, the first one small, below base of pectoral, the last three along side of abdomen being persistent; in larger specimens the first four being reduced to undefined dusky spots; a black spot at base of spinous dorsal; three rows of black to brownish spots along soft dorsal, a narrow dusky strip edged with white forming a row near the tip of each ray; anal with narrow white tip, an indistinct dusky sub-margin, and a narrow dusky band at base, and with a row of blackish to dusky spots; caudal with a large black blotch, with a number of black spots and small white blotches behind and below.

Here described from four specimens, 185.5 to 206 millimeters, from the following localities: LUZON, Batangas Province, Hamilo. TABLAS, Romblon Province, Tablas. BALABAC, Palawan Province, Balabac.

We have also examined a specimen from Japan. None of the specimens was found to have "the oblique brown lines radiating from the lower part of the eye, over the opercles" mentioned by Playfair and Günther.

PARAPERCIS DORSONEBULOSA sp. nov. Plate 2, fig. 2.

Parapercis hexophthalmus JORDAN and SEALE, Bull. U. S. Bur. Fish.
26 [(1906) 1907] 46 (non Bleeker).

Dorsal V, 20 to 21; anal 18; scales on lateral line 60; between lateral line and origin of dorsal 7; between lateral line and origin of anal 17 to 18.

Body elongate, subcylindrical, its depth 5.6 to 5.8 in length; caudal peduncle compressed, its depth 3.1 to 3.4 in head; dorsal and ventral profiles almost equal; head moderate, 3.3 to 3.5, with cheeks full but not bulging; snout gently sloping to spatulate tip, 2.6 to 2.8 in head; eyes large, 4.1 to 4.22; interorbital flat, 12.6 to 19; mouth large, oblique; lips broad; premaxillaries protractile; maxillary entirely concealed under preorbital, its length extending beyond anterior border of eye; lower jaw projecting; upper jaw with an outer series of enlarged teeth coarser in front and posteriorly curved canines on each side; vomer with a narrow band of villiform teeth; opercle with a rather strong spine at upper angle; subopercle terminating in a blunt flat spine.

Dorsal continuous, inserted above and slightly behind base of pectoral; third or fourth dorsal spine longest, equal to diameter of eye or slightly less; anterior dorsal rays as long as distance from snout to behind front margin of pupil or slightly beyond; anal inserted below fifth dorsal ray; pectoral 4.6 to 5.5 in body length; ventrals short, pointed, 4 to 4.8; caudal rounded, with a projecting pointed upper lobe.

Scales somewhat coarsely ctenoid, present all over body and caudal except snout and top and sides of head, smooth scales on cheeks, behind occiput, on breast, and anterior portion of belly.

Ground color in alcohol brownish to yellowish white and brownish above in old specimens. Specimens of three months preservation in alcohol, back dusky with a number of scales here and there splashed with black; a white longitudinal band on side from above base of pectoral to base of caudal; eight to nine dusky crossbars starting from the band and disappearing below distant from median ventral line; eight to nine oblique, narrow, white lines across cheeks and anterior portion of opercle; dorsal with three rows of black dots, uppermost near edge of fin; one on anal; pectoral and ventral white to brownish; caudal with black spots and a large white blotch on posterior two-thirds of middle rays.

Type: No. 31252, in the Bureau of Science collection, 140 millimeters long, collected from Catbalogan, Samar, June, 1934, by Juan Julayco. Three cotypes, one obtained from the same place, and two from Balabac Island, Palawan Province.

Dorsonebulosa, cloudy back, in allusion to the color marking of the back.

PARAPERCIS CLATHRATA Ogilby. Plate 3, fig. 1.

Percis tetracanthus LACÉPÈDE, Hist. Nat. Poiss. 4°. (1803) 285, 302.

Percis tetracanthus BLEEKER, Nat. Tijdschr. Ned. Ind. 4 (1853) 458;

GÜNTHER, Cat. Fish. Brit. Mus. 2 (1860) 241.

Parapercis clathrata OGILBY, Proc. Roy. Soc. Queensl. 23 (1911) 41.

Percis quadrispinosus WEBER, Siboga Exp., Fische (1913) 519.

Parapercis tetracanthus FOWLER, Mem. P. Bishop Mus. 10 (1928) 424.

Dorsal IV, 21; anal 18; scales on lateral line 59 or 60, between lateral line and origin of dorsal 7; between lateral line and origin of anal 15 to 16.

Body elongate, subcylindrical, its depth 5.7 to 6.5 in length; caudal peduncle compressed, its least depth 3.1 to 3.7 in head; dorsal profile more arched than ventral; head slightly depressed, 3.2 to 3.4 in length of body; snout moderate, gently sloping to tip, 2.8 to 3 in head; eye moderate, gently sloping to tip, 2.8 to 3 in head; eye moderate, nearer tip of snout than angle of opercular opening, its upper margin projecting above outline of head, 4 to 4.3 in head; interorbital narrow, 10.8 to 16; mouth moderate, oblique, lips slightly broad, lower jaw projecting; premaxillaries protractile; maxillaries entirely concealed under preorbital, shorter than snout, and sometimes reaching a vertical through anterior border of eyes; upper jaw with an outer series of coarse teeth with several long ones in front and sides, and with an inner villiform band narrowing posteriorly; lower jaw with an outer series of coarse teeth, four in front and three at each side, all enlarged and directed posteriorly, and an inner villiform band which is not continuous behind; vomer with a small patch of small teeth; preopercle entire, opercle with a strong rather flat spine at posterior angle.

Dorsal continuous, third spine longest and as high as vertical diameter of eye; longest rays of dorsal as long as snout or a little longer; anal inserted below fifth dorsal ray; pectoral

rounded, 4.6 to 5.5 in length; ventrals pointed, 4 to 4.57 in length of body.

Scales behind occiput, on cheeks, breast, and abdomen smooth, those on body and caudal finely ctenoid; scales absent on snout, interorbital, sides of head, and occiput.

The following color notes were taken from a live specimen, 107 millimeters long, from Basco, Batanes Province. Ground color brown, each side of body with ten vertical bars which are brown above and red below; vertical bars crossed by two longitudinal bars, upper brown and lower red with black spots; interspaces between vertical and longitudinal bars yellowish, lower parts of body fading into white. Top of head with large round black spots; sides with much smaller ones. Upper part of body brownish with rather indistinct vertical crossbands. Caudal with few black short bars and spots, and brown vertical bars. Dorsal colorless, with two rows of black spots; anal colorless, with black spots behind bases of 6th, 9th, 12th, and 15th rays.

Color in alcohol yellowish to dusky brown, becoming pale brown to white below; top of head with blackish spots, a black ocellus with narrow border of white often appearing only as a black spot immediately above angle of opercular opening; a brown to dusky brown blotch on cheeks below eyes; posteriorly a lighter blotch with black dots, faded in three specimens except for the dots; eleven rather faint crossbands on back, the first connecting the two ocelli on suprascapula and the last on the caudal peduncle; on each side nine vertical bars not continuous with the crossbands on the back; three faint brownish longitudinal bands on each side, one running from the angle of opercle to upper third of caudal peduncle, connected with the crossbands on back and the vertical bands on sides, the second, usually fainter, running straight from upper part of axilla to midst of caudal peduncle, and the third one, absent in some specimens, from immediately below root of pectoral straight to lower part of caudal peduncle; this band is narrower and connects a series of nine to ten black spots on lower part of the vertical bars the first of which lies below root of pectoral and the last on lower part of caudal peduncle; pectoral and ventral white; dorsal with three series of black spots at base of anal

which are absent or very faint in some specimens, and a series of smaller faint spots near the outer edge; caudal with a small white blotch.

Here described from four specimens, 99 to 152 millimeters, from the following localities: BATAAN, Batanes Province, Basco. CAMIGUIN, Cagayan Province, Camiguin. LEYTE, Leyte Province, Cabalian. BALABAC, Palawan Province, Balabac.

We adopt the nom. subst. of Ogilby by priority over the nom. nov. of Weber in accordance with Opinion 1 rendered by the International Commission of Zoölogical Nomenclature.

PARAPERCIS MONTILLAI sp. nov. Plate 3, fig. 2.

Dorsal IV, 21; anal 18; scales in lateral line 60, between lateral line and origin of dorsal 7, between lateral line and origin of ventral 14 to 16.

Body elongate, rather cylindrical, its depth 6 to 6.6 in length; caudal peduncle compressed, its least depth 3.2 to 3.5 in length of head which is 3.2 to 3.4 in length of body; snout rounded at tip, 3 to 3.6; eyes moderate, nearer to tip of snout than to hind edge of opercle, 4.5 to 5; interorbital space very narrow, 17.5 to 22; mouth moderate, oblique; lips slightly broad; premaxillaries protractile; maxillary concealed by preorbital, extending below anterior border of eye; lower jaw projecting; upper jaw with an outer series of enlarged teeth, which are coarse and canine-like anteriorly, and with a band of villiform teeth; lower jaw with three curved canines on each side of symphysis and a villiform band, which becomes a series of coarse teeth posteriorly; vomer with a narrow villiform band; a spine at upper angle of preopercle; subopercle terminates in a rather flat, pointed spine or in a sharp edge.

Dorsal continuous, third spine longest, as long as eye diameter; anal inserted below fifth dorsal ray; ventral pointed and short, 4 to 4.75 in length of body; caudal much rounded.

Scales ctenoid; smooth behind occiput, on cheeks, breast, and belly; snout, and top and sides of head, naked; basal half of caudal scaly.

This species differs from *P. clathrata* in its more rugged appearance and in the more defined outline of the markings, which run from dusky brown to brownish and are arranged more or less in the form of a series of chevrons. Suprascapular ocelli are absent. The markings on the head are in the form of brown blotches. A faint blotch on the anterior portion of the cheek and a darker one behind with three oblique white lines. The

black blotch at lower base of the pectoral forms a line with a series of seven to eight others on side of the belly to the lower side of the caudal peduncle. A posteromedian white blotch on the caudal.

Type: No. 31284, 137 millimeters long, in the Bureau of Science collection, collected by José Montilla, from Calapan, Mindoro, 1931. Four cotypes: One specimen, No. 4382, 134 millimeters long, collected from Zamboanga, Mindanao, June 10, 1908, by Alvin Seale; three others, No. 11438, 90 to 154 millimeters long, collected from Calapan, Mindoro, by Gregorio Lopez, January 17, 1923.

Montillai, for José Montilla, ichthyologist, Bureau of Science, Manila.

ILLUSTRATIONS

PLATE 1

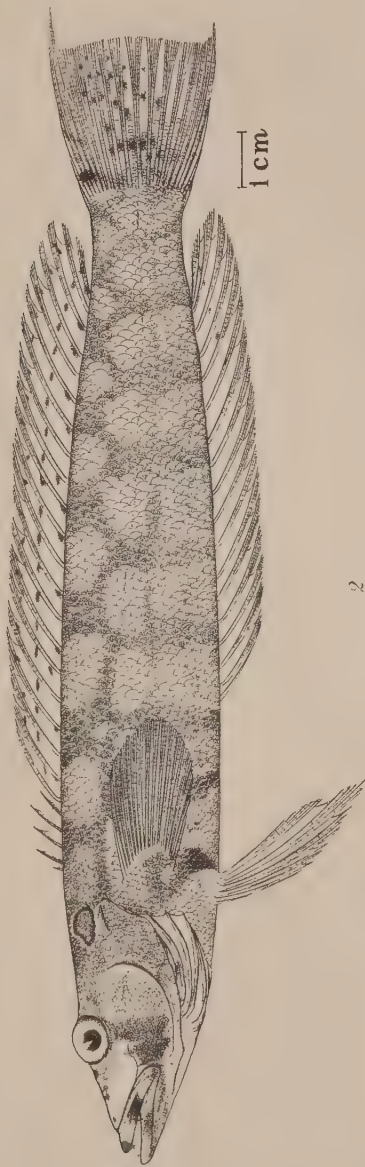
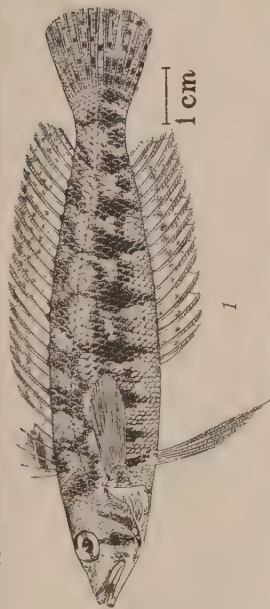
- FIG. 1. *Parapercis cylindrica* (Bloch).
2. *Parapercis tetracantha* (Lacépède).

PLATE 2

- FIG. 1. *Parapercis hexophthalma* (Cuvier and Valenciennes).
2. *Parapercis dorsonebulosa* sp. nov.

PLATE 3

- FIG. 1. *Parapercis clathrata* Ogilby.
2. *Parapercis montillai* sp. nov.



2

PLATE 1.

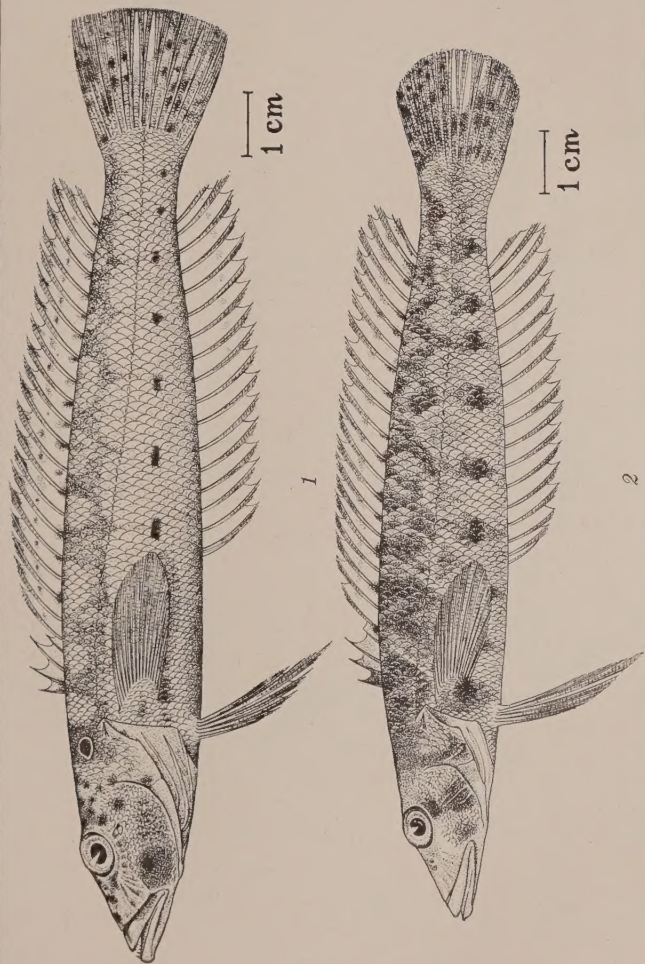


PLATE 2.



